ONW

DELAWARE RIVER BASIN

LAKE LADORE DAM

NDI NO. PA-00091
DER NO. 64-5

LEVEL II

WAYNE COUNTY, PENNSYLVANIA

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE

PREPARED FOR

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

BY

Berger Associates, Inc.
Harrisburg, Pennsylvania

JANUARY 1980

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(6) National Dam Inspection Program. Lake Ladore Dam (NDI Number PA-ØØØ91, DER Number 64-5), Delaware River Basin, Wayne County, Pennsylvania. Phase I Inspection Report ~~PRIPACH~~

This report has been prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

(11) Jan 8Ø (12) 91

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

(15) DACW31-8Ø-C-ØØ19

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT

NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITIONS AND RECOMMENDATIONS

Name of Dam: LAKE LADORE DAM

State & State No.: PENNSYLVANIA, 64-5

County: WAYNE

Stream: VAN AUKEN CREEK

Date of Inspection: October 23, 1979

DACW31-80-C-0019

Based on the visual inspection, past performance and the available engineering data, the dam and its appurtenant structures appear to be in fair condition.

In accordance with the Corps of Engineers' evaluation guidelines, the size classification of this dam is intermediate and the hazard classification is high. The spillway capacity is inadequate to pass the PMF (Probable Maximum Flood) peak inflow without overtopping the dam. The project is capable of passing 57 percent of the PMF and is considered to be inadequate, but not seriously inadequate.

The following recommendations are presented for immediate action by the owner:

(1) That a detailed study be made to determine the cause and origin of leakage and to evaluate the structural stability of the dam. This study to be made by a professional engineer, experienced in the design and construction of dams, should also determine the phreatic line and the condition of the wetwell,

(2) That the spillway en. .ce be cleared of all obstructions,

(3) That the boards in the downstream valve be removed,

(4) That the concrete of the right buttress be repaired,

(5) That all brush be removed from the embankment,

next page

(6) That a formal surveillance and downstream warning system be developed for implementation during periods of heavy or prolonged rainfall,

(7) That a program be developed for regular inspection and maintenance.

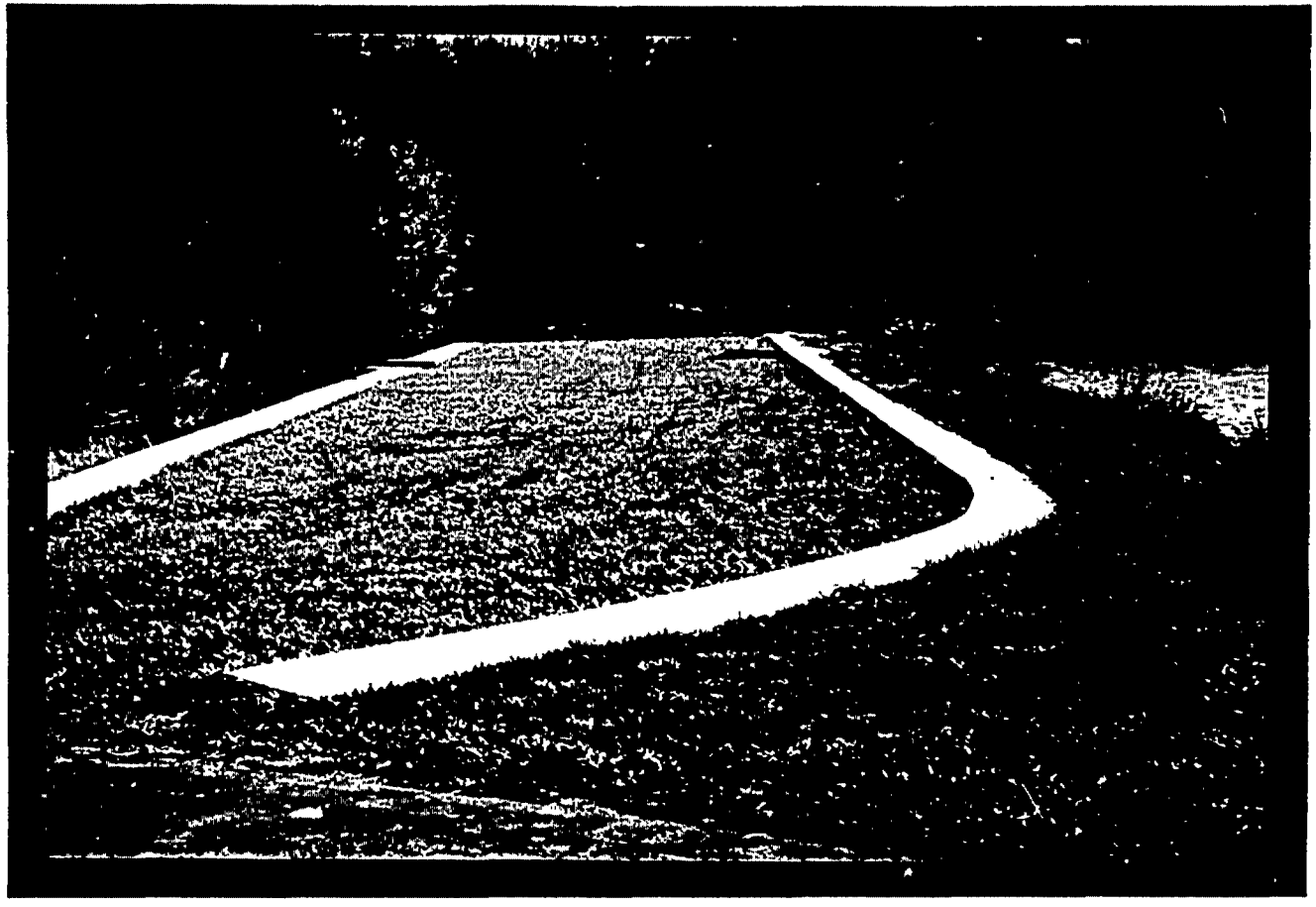
SUBMITTED BY:

BERGER ASSOCIATES, INC.
HARRISBURG, PENNSYLVANIA

DATE: January 25, 1979

APPROVED BY:
JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

DATE: 25 Feb 1980



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OVERVIEW

LAKE LADORE DAM

Photograph No. 1

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE LADORE DAM

NDI-ID NO. PA-00091
DER-ID NO. 64-5

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

A. Authority

The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspections of dams throughout the United States.

B. Purpose

The purpose of this inspection is to determine if the dam constitutes a hazard to human life and property.

1.2 DESCRIPTION OF PROJECT

A. Description of Dam and Appurtenances

Note: Project weir elevation was Elev. 94.6 which was raised to 95.5 during construction in 1922. This report is based on information from U.S.G.S. quadrangle sheet and spillway elevation was set at 1367.0.

The present dam was constructed as two separate structures. The first dam was an upstream embankment with a downstream vertical stone wall and was constructed in 1860. In 1906-07 a new concrete gravity dam was constructed 50 feet downstream of the first dam. In later years, the space between these two dams was filled with soil material and many repairs and improvements have been added. The present dam is about 330 feet long and has a maximum height of 28 feet above streambed. A wetwell has been constructed at the location of the sluiceway in the first dam, with a sluice gate on an 18-inch concrete outlet pipe. The outlet pipe discharges into a junction box located between the two walls and an 18-inch cast iron pipe leads from this junction box through the downstream concrete gravity section (Refer to Plate IX, Appendix E).

A concrete lined spillway was constructed in 1922 at the right abutment. The crest of the spillway weir is about 4 feet below the dam breast and is 50 feet long. The left abutment of the spillway is a vertical concrete wall. The right side of the spillway is excavated into the hillside and has a sloped, rocklined surface. The discharge channel has a concrete slab and is 120 feet long at which point the water drops 8 feet to the natural rock streambed.

B. Location: Canaan Township, Wayne County
U.S.G.S. Quadrangle - Waymart, PA
Latitude 41°-34.7', Longitude 75°-23.2'
Appendix E, Plates I & II

C. Size Classification: Intermediate: Height: 28 feet
Storage: 2718 acre-feet

D. Hazard Classification: High (Refer to Section 3.1.E)

E. Ownership: The Salvation Army
Ladore Camp & Conference Center
Waymart, PA 18472

F. Purpose: Recreation

G. Design and Construction History

The original upstream dam was constructed around 1860 for the Delaware Hudson Canal Company. The reservoir was used as a water supply for the canal and a deep sluiceway with a wooden gate or stoplogs controlled the discharge. No records of the design or construction are existing. In 1906 the owner of the facilities and reservoir was the Lake Ladore Improvement Company, who used the reservoir for ice harvesting and as a summer pleasure resort. In 1906-07 a new rubble concrete gravity dam was constructed about 50 feet downstream of the old dam. This dam was designed by a Mr. Harry Myers of Pittstown, Pa., and was constructed by O'Brien and McLaughlin, Olyphant, Pa. Daily inspection was made by a Mr. Gordon, with overall supervision by the designer. The old dam was left in place. Serious leakage through this concrete dam and through its foundation caused anxiety in the downstream areas (Prompton and Honesdale). Poor design (Plate IV, Appendix E) and construction forced the Water Supply Commission to order a drawdown in 1911. The main reservoir, upstream of the old dam, was lowered 2 feet and the area between the two dams was drained. Mr. John Riegel from the Scranton Engineering Company, Scranton, Pa., reviewed the structure and found it adequate and safe, according to a report dated January 12, 1912. The Water Supply Commission insisted however on strengthening of the dam. Two buttresses located 20 feet to the left and to the right of the spillway were designed by Riegel and added in 1912 (Plates V and VIII, Appendix E).

Due to considerable leakage through the concrete, the deterioration of the concrete and the questionable stability of the gravity section, the reservoir was ordered to be lowered again in 1917. In September 1919 plans were made by Mr. Riegel to place fill between the two dams and to construct a valve pit at the sluiceway of the upstream dam.

Plans were not submitted to the Water Supply Commission and very little progress was made. The owners engaged a new engineer, Mr. Dunning, Scranton, Pa., in December 1920.

Plans were approved in March 1921 which included fill between the two dams, topped with loose stone, wingwalls at end of embankment and using the whole dam section as an overflow section, with a maximum depth of 1 foot. New plans (Plate VI, Appendix E) were submitted at the end of 1921 which included a new spillway in the right abutment and the raising of the drywall of the upstream dam. This work was completed in 1924.

Ownership was transferred in 1933 to the Delaware and Hudson Railroad Company. Serious leakage through the concrete was still occurring at this time. Plans were prepared by the new owner and approved in March 1937. These plans included the raising of the stone wall by another foot, placing additional fill in the upstream slope and the guniting of the upstream and downstream side of the downstream concrete wall. Drainpipes were placed through the wall to relieve hydrostatic pressure. This work was completed in July 1938.

The Salvation Army obtained ownership of the dam in 1960. They engaged Mr. Zimmer, Surveyor, Honesdale, Pa., to study the leakage problem and to improve the spillway. The valve chamber was repaired and a new gate was installed. Both concrete and masonry walls were recapped (Plates IX through XII, Appendix E).

H. Normal Operating Procedures

The reservoir is used for recreation and a pool level at weir crest elevation is desirable. All inflow above this level is discharged over the uncontrolled spillway. The gate in the wetwell, as reported by the owner's representative, is partially opened on an annual basis.

1.3 PERTINENT DATA

A. Drainage Area (square miles)

From files:	2.4
Computed for this report:	3.4
Use:	3.4

B. Discharge at Dam Site (cubic feet per second)
See Appendix D for hydraulic calculations

Maximum known flood (date unknown)	81
Outlet works low-pool outlet at pool Elev. 1356	12
Outlet works at pool level Elev. 1367.0 (spillway crest)	30
Spillway capacity at pool Elev. 1371.0 (top of dam)	1694

C. Elevation (feet above mean sea level)

Top of dam (low point)	1371.0
Spillway crest	1367.0
Upstream centerline intake pipe (estimated)	1354.0
Downstream outlet pipe invert	1345
Streambed at centerline of dam - estimate	1343.0

D. Reservoir (miles)

Length of normal pool	1.3
Length of maximum pool	1.4

E. Storage (acre-feet)

Spillway crest (Elev. 1367.0)	1605
Top of dam (Elev. 1371.0)	2718

F. Reservoir Surface (acres)

Top of dam (Elev. 1371.0)	301
Spillway crest (Elev. 1367.0)	261

G. Dam

Refer to Plate VIII in Appendix E for plan and section.

Type: Upstream dam: Upstream Embankment with downstream masonry wall, capped with concrete.

Downstream dam: Rubble concrete gravity section. Earthfill between the two dams.

Length: 330 feet.

Height: 28 feet above streambed.

Top Width: 73 feet.

Side Slopes: Upstream - Unknown, steep above flowline.
Downstream - Vertical with 4 buttresses.

Zoning: None.

Cutoff: Gravity section placed on rock.

Grouting: None.

H. Outlet Facilities

An 18-inch outlet pipe discharges into a wetwell and valve chamber located on upstream side of centerline of embankment. A sluice gate is on discharge side of wetwell for drawdown. Downstream of the wetwell is an 18-inch outlet pipe. The alignment of this pipe is curved.

I. Spillway

Type: Uncontrolled broad crested weir with sloping crest, concrete paved.

Length: 47 feet.

Channel: Spillway widens to about 60 feet immediately downstream of the upstream edge of the crest, forming a concrete channel. The total length of the channel is 127 feet. At the downstream end is an 8 foot drop to a natural channel. A wooden footbridge crosses the channel.

J. Regulating Outlet

See Section 1.3.H above.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

A. Hydrology and Hydraulics

Engineering data on the hydrology and hydraulic design for these facilities were limited to statements in Reports on Applications for repairs by the Pennsylvania Department on Environmental Resources (PennDER) or its predecessor, the Water Supply Commission.

These reports indicate that the drainage area was assumed to be 2.4 square miles. The concrete gravity dam had a 20 feet long spillway with a one foot depth. The maximum outflow without overtopping was 67 cfs, storage was 255 acre-feet and maximum inflow was assumed to be 800 cfs. The blow-off facility discharge capacity (18-inch pipe) was 40 cfs. The spillway constructed in the right abutment was supposed to be rectangular (60 ft. x 4 ft. deep) and had a discharge rating of 1250 cfs.

B. Embankment and Gravity Section

Information on the design of the upstream dam was not available. Design data and analysis for the downstream dam was not found. After the construction was completed and the stability was questioned, a review of the stability was made by the Scranton Engineering Company (Plate V, Appendix E) and the Water Supply Commission. Reports indicate that the resultant would only fall within the middle third for an 18 ft. height, assuming no uplift. The maximum height was, however, 28 feet. The influence of the buttresses on the stability was neglected.

C. Appurtenant Structures

The available engineering data is limited to the design drawings reproduced in Appendix E.

2.2 CONSTRUCTION

Construction data on the upstream dam is limited to inspection reports by PennDER and some letters from engineers reviewing the stability and safety of the gravity dam.

These reports indicate that blasting was used to excavate the foundation for the gravity dam and the later addition of the buttresses. The foundation material was described as tough green sandstone. The excavation for the buttresses in 1912 showed considerable leakage underneath the dam. The Water Supply Commission reported the foundation as seamy, with considerable leakage through a vertical seam and through the concrete of the dam. Blasting caused additional fissures.

In 1919 some fill was placed between the two dams. The material was obtained from the hillside near the right abutment. Reports indicate that the material was placed loosely and contained many stones and some good sized rock. Because the area between the two dams was drained, the downstream side of the old dam could be inspected. The report indicated that the dry stone wall was in good condition and that some leakage was occurring near the left abutment.

In the early twenties, a concrete cut-off for the sluiceway was constructed (Appendix E, Plate VI). The foundation of this wall was inspected by PennDER and was placed below the timber cribbing forming the sluiceway bottom.

In 1938, fill was excavated on the upstream and downstream side of the gravity wall. A report indicates that the upstream side was in fairly good condition but that the footing appeared to be a dry stone wall rather than concrete. Both faces of the wall were gunited and drainpipes were installed in the wall to relieve hydrostatic pressure behind the wall. It appears also that a drainpipe along the upstream toe was installed, outletting in the old 18-inch blow-off pipe.

Additional construction was performed in 1973 which consisted of repaving of spillway channel, recapping of masonry and gravity wall and repairs to the valve pit.

2.3 OPERATION

There are no formal records of operation maintained. Records of maximum discharges were not found with the owner or in the files of PennDER.

2.4 EVALUATION

A. Availability

The only engineering data available for examination were contained in the files of PennDER, Bureau of Dam Safety. The data was limited to drawings and reports.

B. Adequacy

The available information contained in the files are sufficient to make a reasonable assessment of the overall condition of the dam.

C. Operating Records

Formal operating records are not maintained for this dam. Reports could not be obtained to evaluate maximum flows discharged over the spillway.

D. Post Construction Changes

Many modifications have been made to these facilities, including the construction of a new dam downstream, the filling of the area between the two dams, the raising of the dam, and the construction of a new valve pit and spillway. For detailed discussion of these changes reference is made to Sections 1.2.G and 2.2.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

A. General

The general appearance of the Lake Ladore Dam is fair. The dam has a long history of changes and additions and is a mixture of several different types of construction. Although the upstream portion of the embankment and the top of the dam has a good appearance, the downstream side of the dam, formed by a concrete wall, shows a poor quality of concrete surface and some deterioration. Several weepholes extending through the wall are active, indicating a high phreatic line. The toe below the wall is wet and a steady flow of water was apparent at two locations (Appendix A, Plate A-I).

The reservoir and dam are owned by the Salvation Army, which has a large conference center located close by. The reservoir is used for recreation including fishing, boating and swimming. Mr. Paul Bunting of the Salvation Army accompanied the inspectors during the inspection. The visual inspection check list is in Appendix A of this report. Sketches of a general plan, profile and typical section of the dam, based on the field inspection survey, are also in Appendix A. Photographs of the facilities taken during the inspection are reproduced in Appendix C.

B. Embankment

The upstream section of the embankment is the original structure which was an earthfill dam with a downstream masonry wall. The embankment was raised and the masonry wall was extended by a concrete wall which presently projects above the earthfill. The top of this wall was surveyed as the top profile of the dam. A 14 feet wide earthfill is located upstream of the wall. The upstream slope is very steep to the flow line and is protected against wave action by heavy rock. Some weed and brush growth is present on this slope.

A fifty foot wide earthfill, with the surface sloping about 3 feet to the downstream side, is located downstream of the initial wall. This area has a well maintained grass mat. The downstream side of the dam is formed by a concrete wall, about 3 feet lower than the upstream wall. Originally, this concrete wall had a small spillway with two small buttresses. Two additional buttresses were subsequently added to support the wall. This wall was gunited at a later date. Four drainpipes extend through the wall to the downstream side. Two of these drainpipes are active. One discharges about 5 gallons per minute and the other about 1 gallon per minute. Both drains are approximately 9 feet below the top of the wall. This indicates a high phreatic line at these two pipes. One of the other pipes was crushed. The top of the wall has been recapped and is in good condition. The gunite surface on the downstream side shows many cracks and is deteriorated at many locations.

The ground surface at the toe of the wall is saturated between the added buttress and the old spillway buttress (See Plate A-I, Appendix A) and two streams of steady flow were apparent at the corners of the buttresses. The concrete of one buttress has spalled exposing the reinforcing steel.

C. Appurtenant Structures

The spillway, which was added to this facility in 1922 is located in the right abutment. The approach to the spillway is directly from the reservoir. The entrance to the right side is partially obstructed by high weeds. The spillway weir is a broad crested type and not very level. There is about a 2-inch drop from right to left (See Plate A-II, Appendix A). The spillway has a concrete abutment wall on the left side and a sloped natural rock surface on the right side. The discharge channel is 118 feet long and drops at a 4 percent grade. The slab is showing some deterioration, but is in fairly good condition. The left side and the end of the discharge channel are protected with concrete walls.

A temporary footbridge has been constructed over the spillway. This narrow wooden structure is supported on several 4' x 4's and a barrel (See Appendix C, Plate C-IV). The structure would probably wash away if a heavy discharge would occur.

A wetwell is located between the two masonry walls just downstream from the original wall. The wetwell is covered with a heavy steel plate and contains a sluice gate, which is operated annually. The outlet conduit from the wetwell is an 18-inch pipe. The pipe discharges to the right of the old spillway adjacent to a buttress. A 20-inch gate at the downstream end of this pipe is not in working coudition. This gate is blocked by some boards. Water is continually discharging through the pipe to maintain minimum flow. According to Mr. Bunting, the control gate in the wetwell is never completely closed.

D. Reservoir Area

The reservoir is surrounded by woodlands on moderate slopes. The banks appear to be stable and sedimentation has not been reported to be a problem in the reservoir.

E. Downstream Channel

The spillway discharges at the end of the chute over an 8 foot vertical drop into a rock lined channel in a wooded area. The stream slopes about 80 feet in 1,500 feet at which point the stream enters a downstream reservoir called Keen Lake. Several homes, cottages and a camping ground are located around this lake. About 6 houses are located below Keen Lake Dam in an area which would be flooded if Keen Lake Dam

should fail due to failure of the Lake Ladore Dam. The hazard category of Lake Ladore Dam is considered "High."

3.2 EVALUATION

The visual evaluation of the facilities at Lake Ladore Dam is fair. An accurate assessment of the stability of the dam cannot be made due to the many changes and additions. The main concern is the seepage at the toe of the downstream wall and the active discharge through 2 weepholes. These conditions indicate a high phreatic line in the earthfill, and that a pervious or semi-pervious material was used for the fill between the two walls. Another possibility is that the downstream concrete wall prevents the normal seepage to pass out of the fill and that this generates a hydrostatic pressure behind the wall.

The top of the dam is well maintained. Although the upstream slope appears to be steep, good rock protection is present and no failures were detected.

The spillway, while not entirely level, is in good condition. The entrance should be kept free of weeds and brush. The footbridge was probably placed without a permit. It appears that this bridge would be washed away during high flow and would not seriously impede the capacity of the spillway.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The operational procedures at Lake Ladore Dam are limited. The reservoir is used for recreation and the pool level is maintained at the elevation of the spillway weir. Any additional inflow is discharged over the uncontrolled broadcrested weir.

4.2 MAINTENANCE OF EMBANKMENT

The recently restored top of the concrete walls is in good condition. The top of the embankment has a well maintained grass mat. There is some brush growing on the upstream slope, which needs removal.

4.3 MAINTENANCE OF OPERATING FACILITIES

The entrance to the spillway should be cleared to provide for unobstructed discharge. The annual opening of the gate in the wetwell should be continued.

4.4 WARNING SYSTEM

Although the top of the dam is observed daily by maintenance personnel, this observation is limited to a policing function. A formal surveillance plan and downstream warning system does not exist at present.

4.5 EVALUATION

The operational and maintenance procedures for these facilities should be expanded to include brush removal on the upstream slope and in the spillway area. Regular observance of the upstream slope should be included in the maintenance program to ascertain that no failures in the steep rock slope has occurred. The weepholes on the downstream wall should be observed to evaluate if higher pool levels would cause fines to be washed out. A formal surveillance plan and downstream warning system should be developed for implementation during periods of high or prolonged precipitation.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 EVALUATION OF FEATURES

A. Design Data

The hydrologic and hydraulic analyses available from PennDER for Lake Ladore Dam were not extensive. No frequency curve, unit hydrograph, nor flood routings were submitted by the designer to PennDER.

B. Experience Data

The maximum recently known flood at Lake Ladore Dam caused the pool level to rise to 8 inches above the spillway crest. The storm was passed without difficulty.

C. Visual Observations

On the date of the inspection no conditions were observed that would indicate that the appurtenant structures of the dam could not operate satisfactorily during a flood event, until the dam is overtopped.

D. Overtopping Potential

Lake Ladore Dam has a total storage capacity of 2,718 acre-feet and the overall height is 28 feet above the streambed. These dimensions indicate a size classification of "Intermediate". The hazard classification for this dam is "High" (See Section 3.1.E).

The recommended Spillway Design Flood (SDF) for a dam having the above classifications is the PMF (Probable Maximum Flood). For this dam the PMF peak inflow is 6,030 cfs (See Appendix D for hydraulic calculations).

Comparison of the estimated PMF peak inflow of 6,030 cfs with the estimated discharge capacity of 1,694 cfs indicates that a potential for overtopping of the Lake Ladore Dam exists. This discharge is based on the present low point in the crest at Elev. 1,371.

An estimate of the storage effect of the reservoir and routing of the computed inflow hydrograph through the reservoir shows that this dam does not have the necessary storage available to pass the PMF without overtopping. The spillway-reservoir system can pass a flood event equal to 57% of a PMF, based on the present low point in the crest profile.

E. Spillway Adequacy

The intermediate size and high hazard categories, in accordance with the Corps of Engineers criteria and guidelines, indicates that the Spillway Design Flood (SDF) for this dam should be the Probable Maximum Flood.

Calculations show that the spillway discharge capacity and reservoir storage capacity combine to handle 57% of the PMF (Refer to Appendix D). If the low point in the embankment would be raised to Elev. 1371.2, making the crest elevation uniform, the spillway discharge capacity and reservoir storage capacity would handle approximately 61% of the PMF.

Since the spillway discharge and reservoir storage capacity cannot pass the full PMF without overtopping, but can pass more than one-half the PMF without overtopping, the spillway is considered to be inadequate but not seriously inadequate.

The hydrologic analysis for this investigation was based upon existing conditions of the watershed. The effects of future development were not considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

A. Visual Observations

1. Embankment

The visual observation of this structure indicates a very high phreatic line behind the downstream concrete wall (active drainpipes) and possible seepage through the foundation (soggy toe). The top of the structure is quite wide and well maintained, with a good grass mat. There were no indications that any movement has occurred in the downstream wall, and it appears that the embankment with its two walls are stable. Although the upstream slope was steep, the riprap protection is apparently stable. Reference is made to the Geologic Report, Appendix F, for discussion of the foundation.

2. Appurtenant Structures

A small amount of deterioration has occurred in the spillway slab, but the overall condition of the spillway appears to be adequate at the present time. The left wall is solid and the rock surface on the right side appears sufficient to withstand expected discharges.

The wetwell could not be inspected and the operational condition of the sluice gate was not ascertained during the inspection. Although the downstream valve is not usable, its function is not important from a structural point of view. It is recommended to remove the boards in this valve, because this cannot be done when full hydrostatic pressure is present in the outlet pipe. The existing condition would prevent full use of the discharge capacity in case of an emergency.

B. Design and Construction Data

1. Embankment

Detailed information is not available about the structural stability of this structure as it exists today. Reports indicate that some leakage at the left abutment occurred in the upstream dam. The dry stone wall was reported to be in good condition during a dewatering period in the twenties. The structural stability of the downstream concrete gravity wall was questioned and reevaluated. Reports and force diagrams indicate that the resultant falls outside the middle third for the maximum section. Although two buttresses were added, the design of the wall would not be acceptable if this wall was the only retaining feature. There is, however, a large amount of fill in front of this wall including the old masonry wall. If the downstream wall should fail, progressive recession could occur. The present available information is not adequate to evaluate the stability and structural integrity of the embankment.

2. Appurtenant Structures

The available design and construction data is limited to the design drawings. Design assumptions and calculations could not be found. A point of concern is the presence of the wetwell in the fill and the many times the outlet pipe was reconstructed and attached to the cast iron pipe through the downstream wall. Leakage through the wetwell walls and pipe could exist.

C. Operating Records

There are no operating records for this dam. Inspection reports indicate that leakage has been a problem since 1906.

D. Post Construction Changes

The construction of many of the changes to this dam since 1906 have been made haphazardly without good engineering design and supervision. Construction was often over long periods of time without trying to rectify the actual stability and leakage problems. The quality of concrete in the gravity dam was poor and the fill between the dams was constructed of poor material and without good compaction methods.

E. Seismic Stability

This dam is located in Seismic Zone 1 and it is considered that the static stability is sufficient to withstand minor earthquake-induced dynamic forces. No studies or calculations have been made to confirm this assumption.

SECTION 7 - ASSESSMENT AND RECOMMENDATIONS

7.1 DAM ASSESSMENT

A. Safety

The visual inspection and the review of available information indicate that the dam and its appurtenant structures are in fair condition. The inspection did not detect any signs of present instability of the dam, but the suspected high phreatic line in the fill and the soggy condition along the toe are points of concern. The design reviews made by PennDER indicate that the downstream dam was not designed in accordance with accepted engineering practice. Although the dam does not show signs of instability, further studies are recommended to evaluate the safety of the structure.

In accordance with the Corps of Engineers evaluation guidelines, the spillway is inadequate for passing the full PMF peak inflow without overtopping the dam. The combination of storage and spillway capacity is sufficient for passing 57 percent of the PMF and although the spillway is inadequate, it is not considered to be seriously inadequate. If the low areas were raised to the design crest elevation, the project would pass approximately 61 percent of the PMF without overtopping the dam.

B. Adequacy of Information

Although the available engineering data are not sufficient to make a detailed analysis of the stability of the dam and its appurtenant structures, the available drawings, reports and the observed physical conditions are judged sufficient for making a reasonable assessment of the overall condition of the dam.

C. Urgency

The recommendations presented below should be implemented without delay.

D. Necessity for Additional Studies

Additional studies will be required to ascertain the stability of dam, and to evaluate the cause and consequences of the apparent high phreatic line in the fill.

7.2 RECOMMENDATIONS

In order to assure the safe operation of this dam, the following recommendations are presented for implementation by the owner:

1. That a detailed study be made to determine the cause and origin of leakage and to evaluate the structural stability of the dam. This study shall include, but not be limited to the determination of the phreatic line, the condition of the wet-well and outlet and the possible results if the downstream wall of this dam would fail due to overturning. The study is to be made by a Professional Engineer with experience in the design and construction of dams.

2. That the spillway entrance be cleared of grass, weeds and other obstructions.

3. That the boards in the downstream valve be removed.

4. That the concrete of the right buttress be repaired and protected from further deterioration.

5. That the brush on the upstream slope be removed.

6. That a formal surveillance and downstream warning system be developed for implementation during periods of heavy or prolonged rainfall.

7. That a program be developed for regular inspection and maintenance of the dam and its appurtenant structures.

APPENDIX A

CHECKLIST OF VISUAL INSPECTION REPORT

CHECK LIST

PHASE I - VISUAL INSPECTION REPORT

PA DER # 64-5 NDI NO. PA-00 091

NAME OF DAM LAKE LADORE DAM HAZARD CATEGORY High

TYPE OF DAM Earthfilled concrete masonry cell

LOCATION Canaan TOWNSHIP Wayne COUNTY, PENNSYLVANIA

INSPECTION DATE 10/23/79 WEATHER sunny, windy TEMPERATURE 60's

INSPECTORS: R.V. Houseal (Recorder) OWNER'S REPRESENTATIVE(s):

H. Jongsma Paul Bunting

R. Shireman

A.L. Bartlett

NORMAL POOL ELEVATION: 1367.0 AT TIME OF INSPECTION:

BREAST ELEVATION: 1371.2 POOL ELEVATION: 1367

SPILLWAY ELEVATION: 1367.0 U.S.G.S. TAILWATER ELEVATION:

MAXIMUM RECORDED POOL ELEVATION: Unknown (Estimated 1367.67)

GENERAL COMMENTS:

Owner's representative (3 years here) indicated about 8" max. over spillway. Usually 1"± on embankment side of spillway. Dry in some months of summer.

This dam is concrete and masonry cell with earthfill in the center. Tops of concrete cell recently capped and appear in good condition. Earth embankment is limited to upstream of wall 14' then almost vertically to water surface. Water going over left side of spillway due to wave action.

NDI NO. PA-00 091

VISUAL INSPECTION
EMBANKMENT

	OBSERVATIONS AND REMARKS
A. SURFACE CRACKS	There is no earth embankment as such. Earthfill is contained within concrete and concrete masonry walls. Upstream portion is earth.
B. UNUSUAL MOVEMENT BEYOND TOE	None observed.
C. SLOUGHING OR EROSION OF EMBANKMENT OR ABUTMENT SLOPES	None observed.
D. ALIGNMENT OF CREST: HORIZONTAL: VERTICAL:	Horizontal alignment is good. Vertical - See Profile Plate A-II, Appendix A.
E. RIPRAP FAILURES	Large rocks & boulders along upstream face of dam embankment. Covered with weed and brush growth.
F. JUNCTION EMBANKMENT & ABUTMENT OR SPILLWAY	Left side abutment is with natural ground. Right side abuts with concrete spillway and channel walls.
G. SEEPAGE	Pipes extending through the downstream face of wall are discharging water. Blow-off pipe is discharging also. Some seepage beneath wall - See sketch, Plate A-I.
H. DRAINS	Several 2" dia. pipes extend through the downstream concrete wall.
J. GAGES & RECORDER	None.
K. COVER (GROWTH)	Top surface is closely cropped grass. Upstream riprap to flow line. Downstream concrete wall with buttresses.

NDI NO. PA-00 091

VISUAL INSPECTION
OUTLET WORKS

	OBSERVATIONS AND REMARKS
A. INTAKE STRUCTURE	Concrete wetwell with gate valve.
B. OUTLET STRUCTURE	Control for blow off is located on the downstream side of the upstream wall of the concrete cell. Valve is always slightly open. It is operated about one time each year.
C. OUTLET CHANNEL	20-inch valve on an 18-inch pipe.
D. GATES	In wetwell and downstream.
E. EMERGENCY GATE	Same.
F. OPERATION & CONTROL	Gate opened about once a year.
G. BRIDGE (ACCESS)	None.

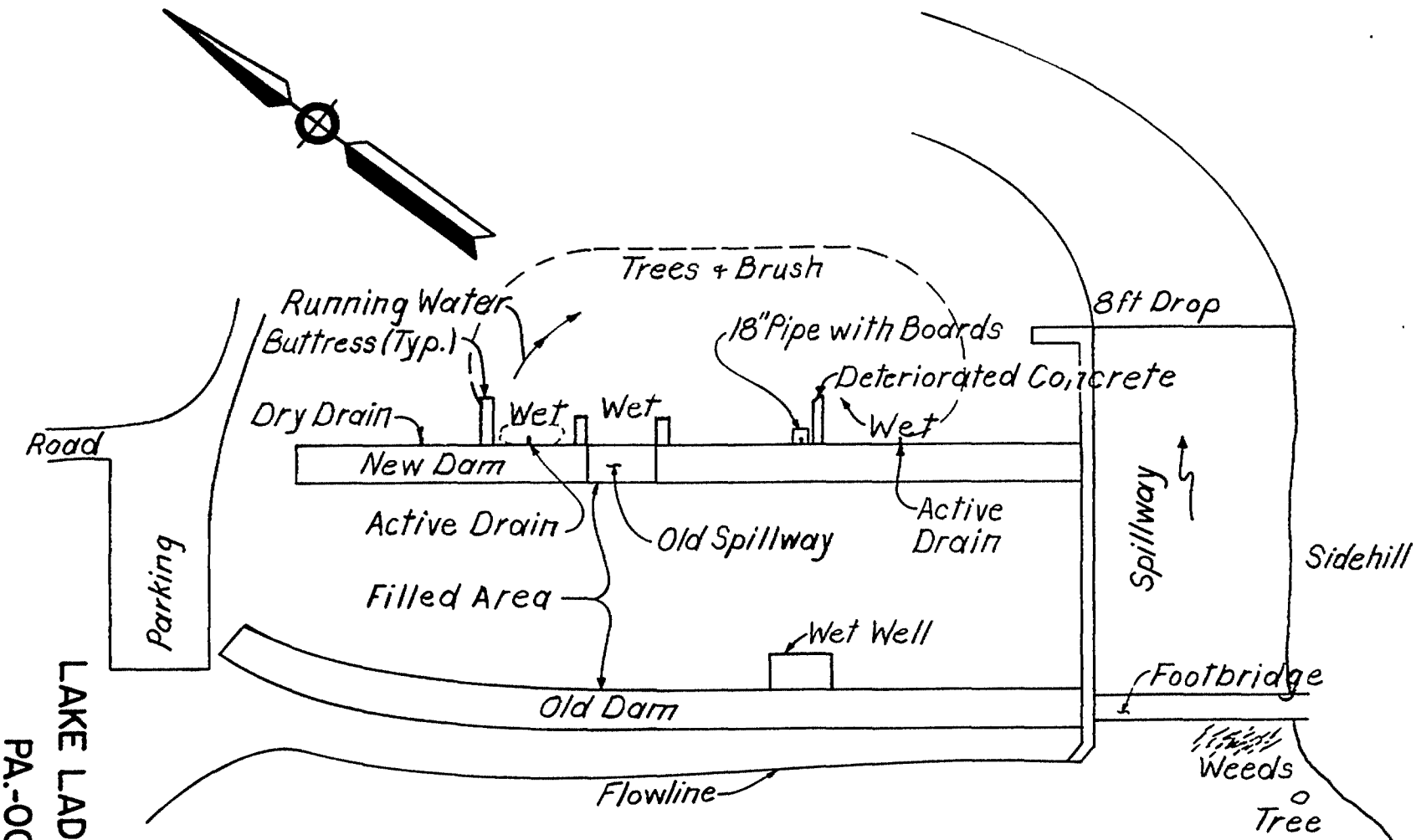
NDI NO. PA-00 091

VISUAL INSPECTION
SPILLWAY

	OBSERVATIONS AND REMARKS
A. APPROACH CHANNEL	Approach channel is directly from the reservoir area. There is no channel. Entrance is partially obstructed on right side by weeds.
B. WEIR: Crest Condition Cracks Deterioration Foundation Abutments	Broadcrested weir with concrete wall on the left and natural ground and woods on the right.
C. DISCHARGE CHANNEL: Lining Cracks Stilling Basin	Bottom of channel is paved with concrete and shows signs of wear. The channel chute is 120 feet in length. At this point there is an 8 foot vertical drop onto rocks in the stream channel.
D. BRIDGE & PIERS	A wooden foot bridge provides access across the spillway. It is a temporary structure in fair condition (no handrail) and supported on several posts and an empty barrel.
E. GATES & OPERATION EQUIPMENT	None.
F. CONTROL & HISTORY	None.

VISUAL INSPECTION

	OBSERVATIONS AND REMARKS
INSTRUMENTATION Monumentation	None.
Observation Wells	None.
Weirs	None.
Piezometers	None.
Staff Gauge	None.
Other	None.
RESERVOIR Slopes	The reservoir is surrounded with woodlands. The slopes are moderate - 8% to 10% toward lake area and stable.
Sedimentation	None reported.
Watershed Description	Woodlands and forests - minimum developed lands.
DOWNSTREAM CHANNEL Condition	Wooded in the overbank areas - rock bottom in the channel. Another reservoir downstream.
Slopes	Wooded moderate 8° - 10°.
Approximate Population	20 plus campers.
No. Homes	Keen Lake camp ground and then 6 homes in flood plain.



SCHEMATIC PLAN

Surveyed 10-23-79

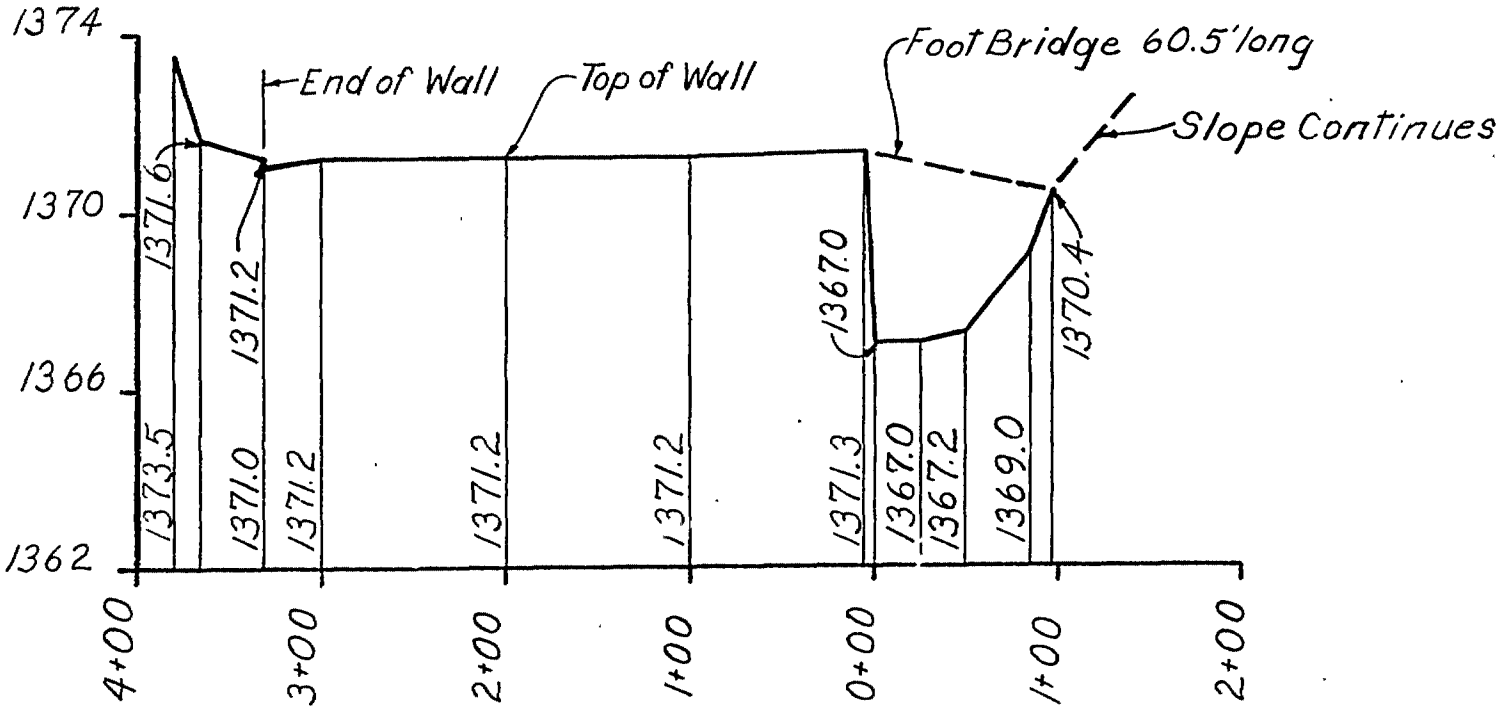
LAKE LADORE DAM
PA-00091
INSPECTION SURVEY
PLATE A-I

LAKE LADORE DAM

PA.-00091

INSPECTION SURVEY

PLATE A-II



EMBANKMENT PROFILE

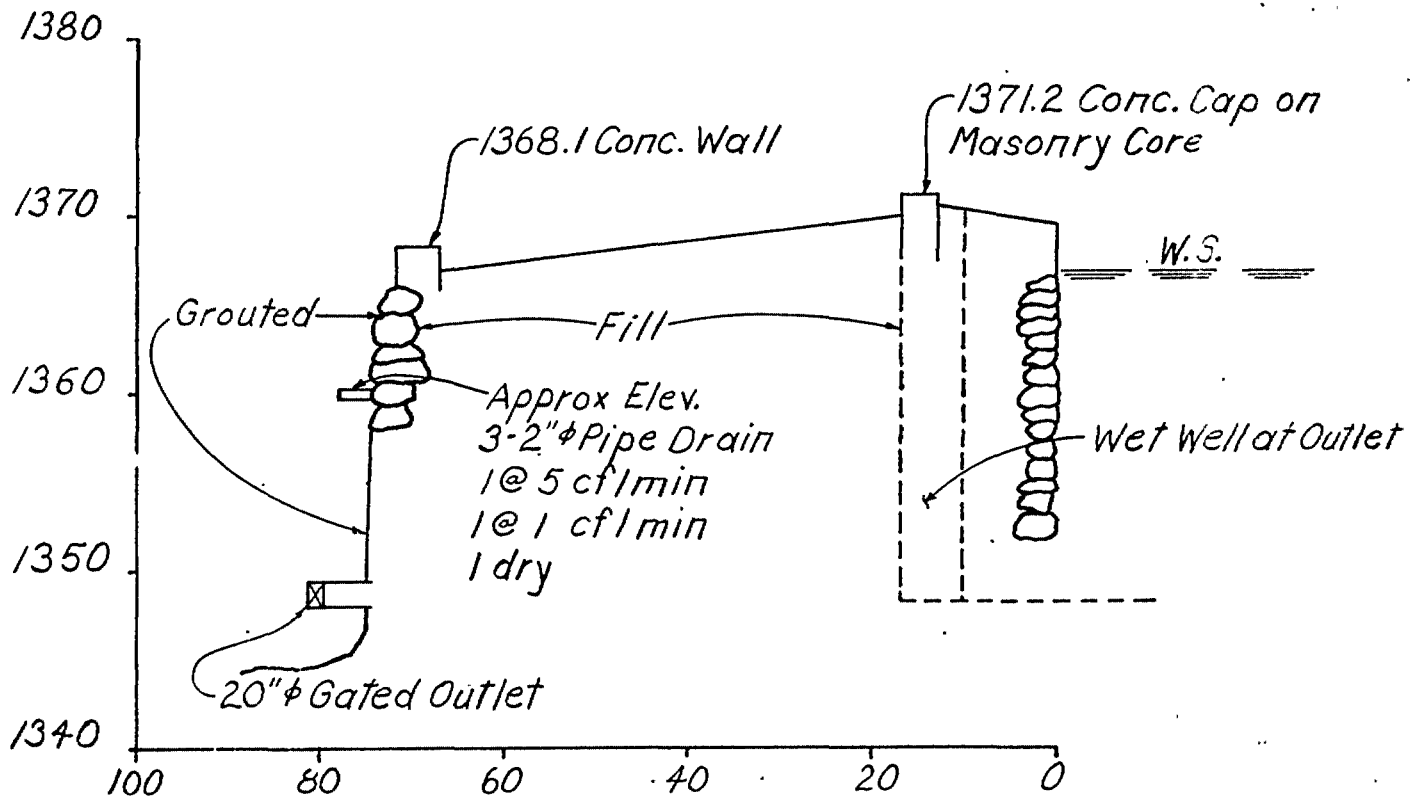
Surveyed 10-23-79

LAKE LADORE DAM

PA.-00091

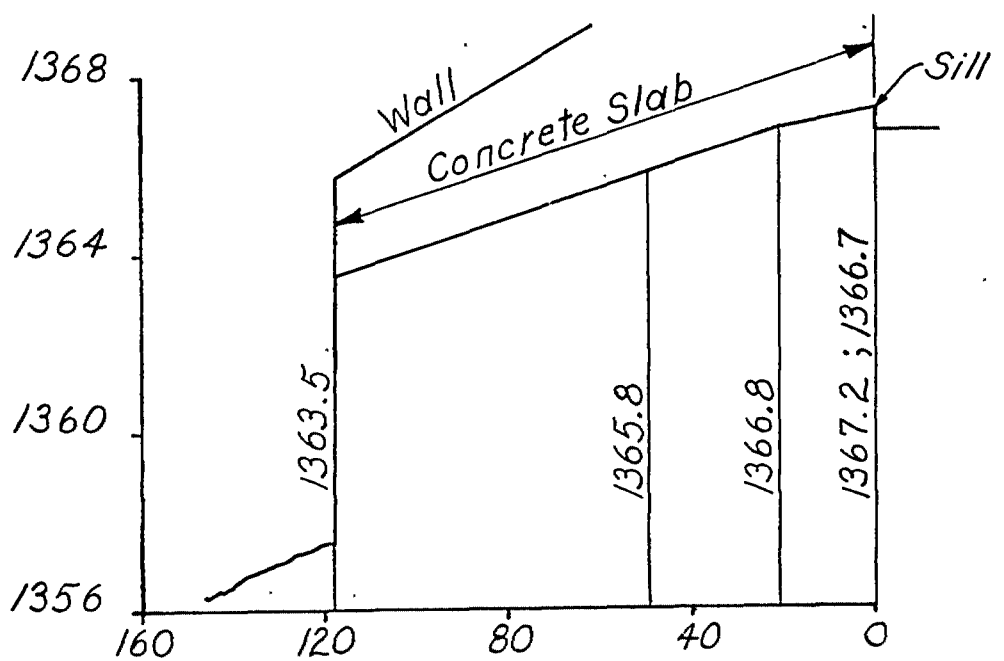
INSPECTION SURVEY

PLATE A-III



EMBANKMENT SECTION

Surveyed 10-23-79



SPILLWAY PROFILE

Surveyed 10-23-79

LAKE LADORE DAM
PA.-00091
INSPECTION SURVEY
PLATE A-IV

APPENDIX B

CHECKLIST OF ENGINEERING DATA

CHECK LIST
ENGINEERING DATA

PA DER # 64-5 NDI NO. PA-00091

NAME OF DAM LAKE LADORE DAM

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. Quadrangle Waymart, Pa. See Plate II, Appendix E
CONSTRUCTION HISTORY	First dam constructed in 1860. A concrete gravity dam was constructed in 1906, about 50 feet downstream. Many changes were made over the years and fill was placed between the dams in 1923. A spillway was constructed in 1923.
GENERAL PLAN OF DAM	See Appendix E, Plate VIII.
TYPICAL SECTIONS OF DAM	See Appendix E, Plate X.
OUTLETS: PLAN DETAILS CONSTRAINTS DISCHARGE RATINGS	See Appendix E, Plates VI & IX. None.

NDI NO. PA-00091

ENGINEERING DATA

ITEM	REMARKS
RAINFALL & RESERVOIR RECORDS	None.
DESIGN REPORTS	None.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS: HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None.
MATERIALS INVESTIGATIONS: BORING RECORDS LABORATORY FIELD	None.
POST CONSTRUCTION SURVEYS OF DAM	Field sketches by Engineers for indicating changes and repairs. Appendix E, Plates III, IV, V, VI & VII.
BORROW SOURCES	Material for fill between dams was probably obtained from hillside at right embankment.

ENGINEERING DATA

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	1906 - Downstream dam. 1912 - Buttresses added to downstream dam. 1922 - Valve pit and fill between dams. Spillway added. Stone wall raised. 1938 - Stone wall raised. Downstream dam gunited. 1973 - Spillway repaired, valve pit changed, wall capped.
HIGH POOL RECORDS	No records.
POST CONSTRUCTION ENGINEERING STUDIES & REPORTS	Many inspection reports and reports upon application for repairs by PennDER.
PRIOR ACCIDENTS OR FAILURE OF DAM Description: Reports:	No failures reported.
MAINTENANCE & OPERATION RECORDS	No records by owner.
SPILLWAY PLAN, SECTIONS AND DETAILS	See Appendix E, Plates VI & VIII.

NDI NO. PA-00091

ENGINEERING DATA

ITEM	REMARKS
OPERATING EQUIPMENT, PLANS & DETAILS	One sluice gate in valve pit. Appendix E, Plate XI.
CONSTRUCTION RECORDS	Inspection Reports by PennDER.
PREVIOUS INSPECTION REPORTS & DEFICIENCIES	Inspection Reports by PennDER since 1911. All reports indicate considerable seepage through concrete gravity dam. Inadequate stability of downstream dam.
MISCELLANEOUS	See attached sheets for additional information.

Highlights of Inspection Reports and Other Reports

1906 - Upstream dam was deemed unsafe due to leakage. New concrete gravity dam constructed 50 feet downstream. Same height (23 ft.), spillway 20 ft. x 1 ft.

1911 - New dam deemed unsafe due to poor concrete quality and severe leakage.

Dec. 1912 - Owner ordered to drawdown reservoir. Main reservoir lowered 2 ft. and reservoir between 2 dams drawn down.

Jan. 1912 - Scranton Engineering Co. reports dam as safe. Water Supply Commission disagrees.

May 1912 - Plans for two additional buttresses approved. Excavation indicates serious leakage through foundation.

Oct. 1912 - Buttresses completed. State Engineer doubts adequacy of buttresses.

May 1917 - Flashboards in spillway, maintaining pool level 4.5 inches below top of dam. Considerable leakage, concrete deteriorating.

Nov. 1917 - Flashboards removed. Report states that insufficient sand and cement was used in concrete for gravity dam. Stability analysis indicates that force resultant falls outside middle third for height over 18 feet. No danger for dam due to presence of upstream dam. Sealing of concrete dam suggested. Owner directed to lower reservoir 4 feet.

June 1919 - Considerable leakage. Soggy toe. Lower reservoir level.

Sept. 1919 - Plans to fill between dams and construct valve pit.

Oct. 1919 - Fill material placed loosely with large rock. Upstream dam in good condition.

March 1920 - Mr. Dunning, Scranton submits plans, using full length of dam as spillway.

May 1921 - No work has been performed. Flashboards raises level to top of dam.

Oct. 1921 - Mr. Dunning recommends new spillway in right abutment and to raise masonry wall of upstream dam.

Nov. 1921 - Plans approved. Spillway .9 ft. higher than shown on plans. Requires raising dam to 99.5.

June 1923 - Fill placed in sluiceway not tamped and containing roots and large stones. Directed to remove poor material.

July 1924 - Repair work completed. Leakage around cutoff wall in sluiceway.

Oct. 1936 - Continuing leakage. Grass and shrubs on downstream wall. Erosion of spillway slab. Crest of dam 8 inches below spillway abutment wall.

Dec. 1936 - Plans submitted for repairs and to raise drystone wall.

Sept. 1937 - No repairs made.

May 1938 - Excavation along upstream and downstream side of gravity wall completed. Reservoir lowered. New fill placed on upstream side of old dam with riprap. Upstream dam leaks 150 feet from left end. Poor base noticed on gravity dam. Wall gunited on both sides. Drain pipes installed through wall and along upstream toe of gravity dam.

1948 - 1969 - Nothing reported. Dam in excellent condition.

NDI NO. PA-00091

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Small urban area, mostly woodlands and agricultural.

ELEVATION:

TOP NORMAL POOL & STORAGE CAPACITY: Elev. 1367 1605 Acre-Feet

TOP FLOOD CONTROL POOL & STORAGE CAPACITY: Elev. 1371 2718 Acre-Feet

MAXIMUM DESIGN POOL: Elev. 1371.2

TOP DAM: Elev. 1371.2

SPILLWAY:

a. Elevation 1367

b. Type Uncontrolled broadcrested

c. Width 47 feet

d. Length 127 feet

e. Location Spillover right abutment

f. Number and Type of Gates None

OUTLET WORKS:

a. Type 18 inch pipe with sluice gate in wetwell

b. Location near center of embankment

c. Entrance ~~xxxxxxx~~ centerline 1354

d. Exit inverts 1354

e. Emergency drawdown facilities sluice gate

HYDROMETEOROLOGICAL GAGES:

a. Type None

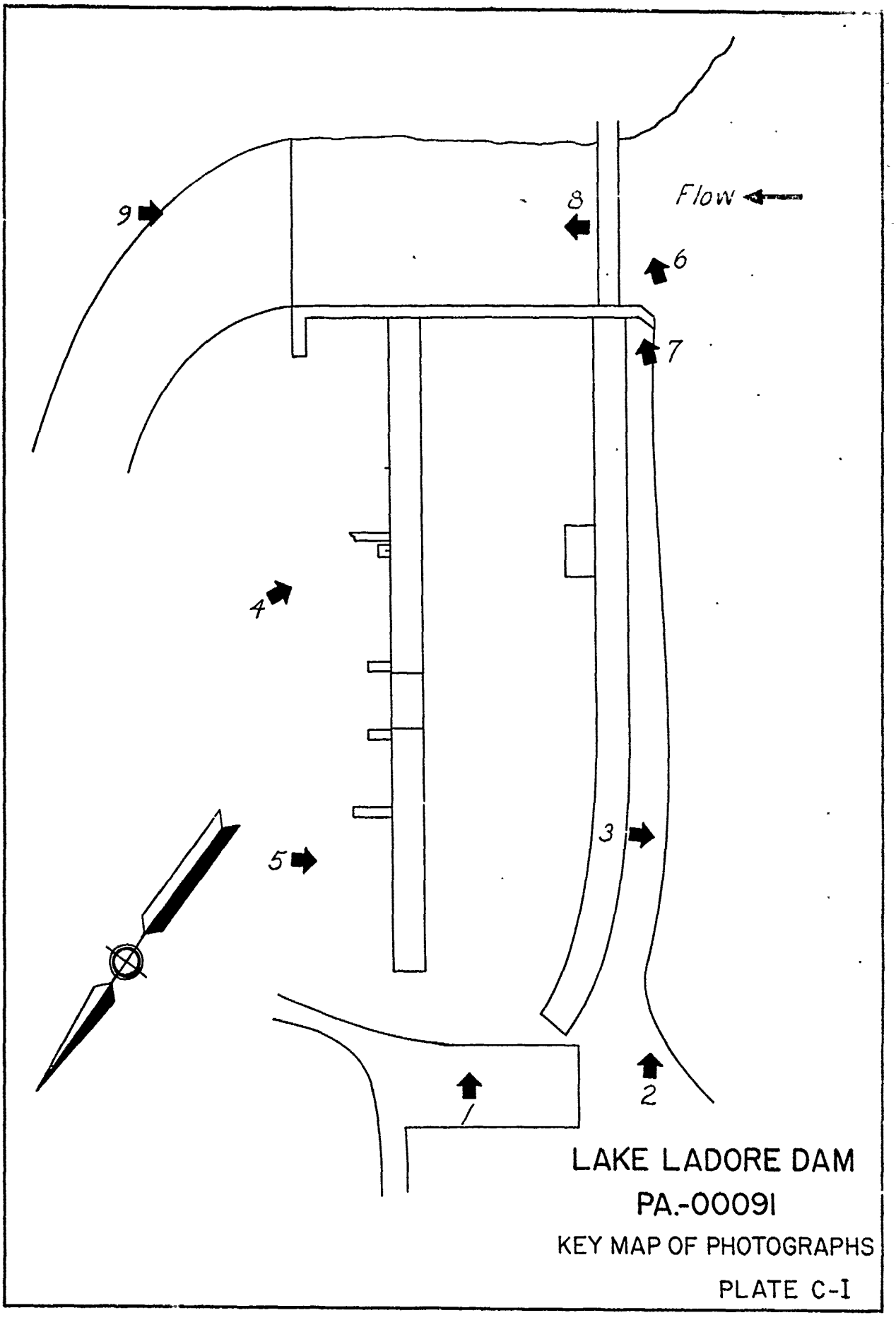
b. Location None

c. Records None

MAXIMUM NON-DAMAGING DISCHARGE: 1694 cfs

APPENDIX C

PHOTOGRAPHS

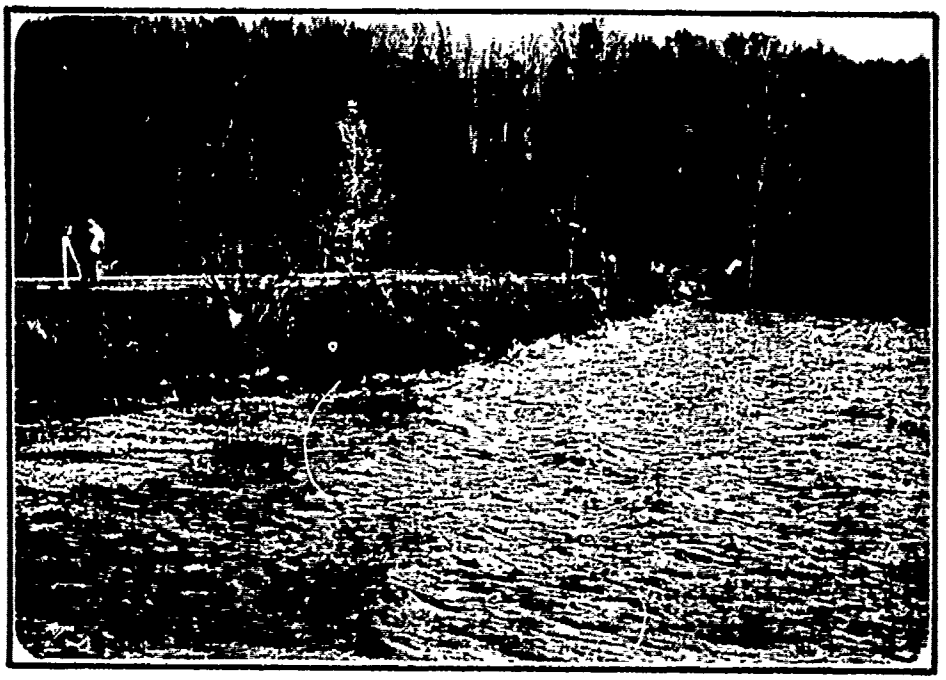


LAKE LADORE DAM

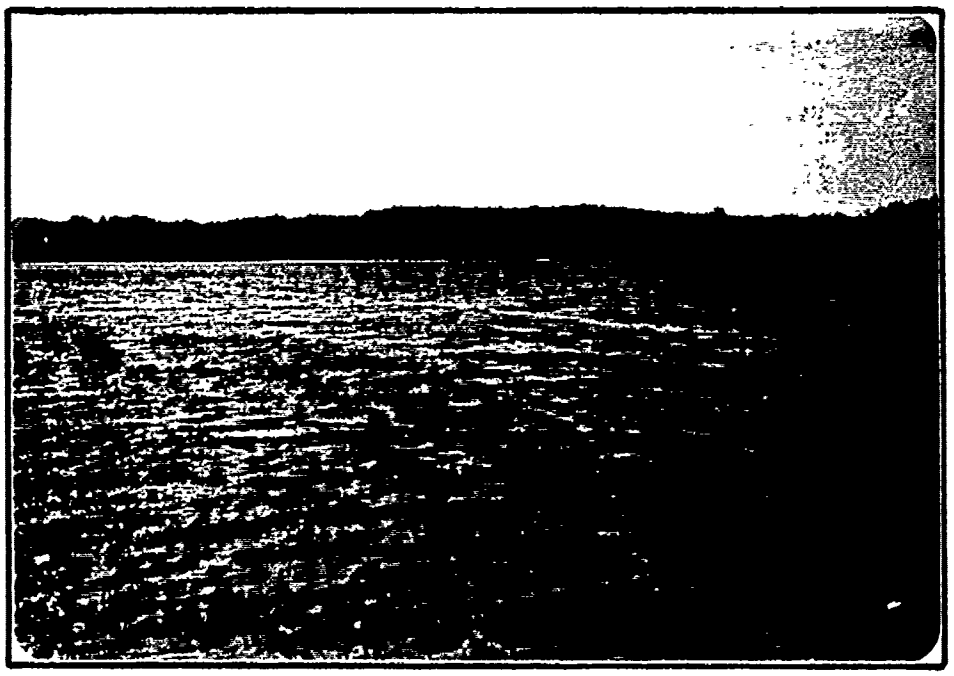
PA.-00091

KEY MAP OF PHOTOGRAPHS

PLATE C-I



UPSTREAM SLOPE - NO. 2



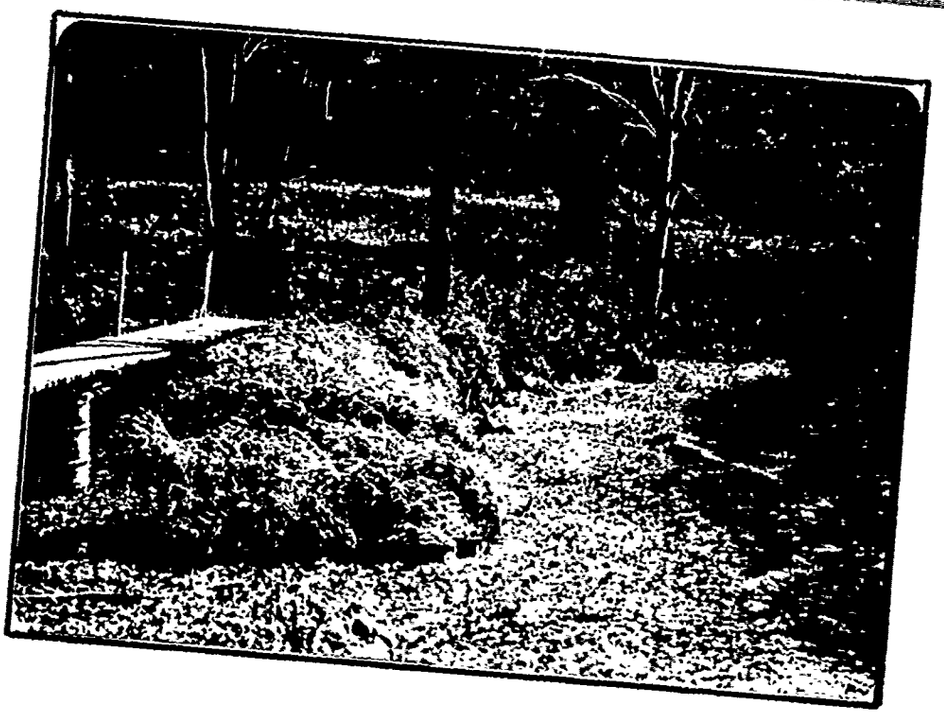
RESERVOIR AREA - NO. 3

PA-00091
Plate C-II

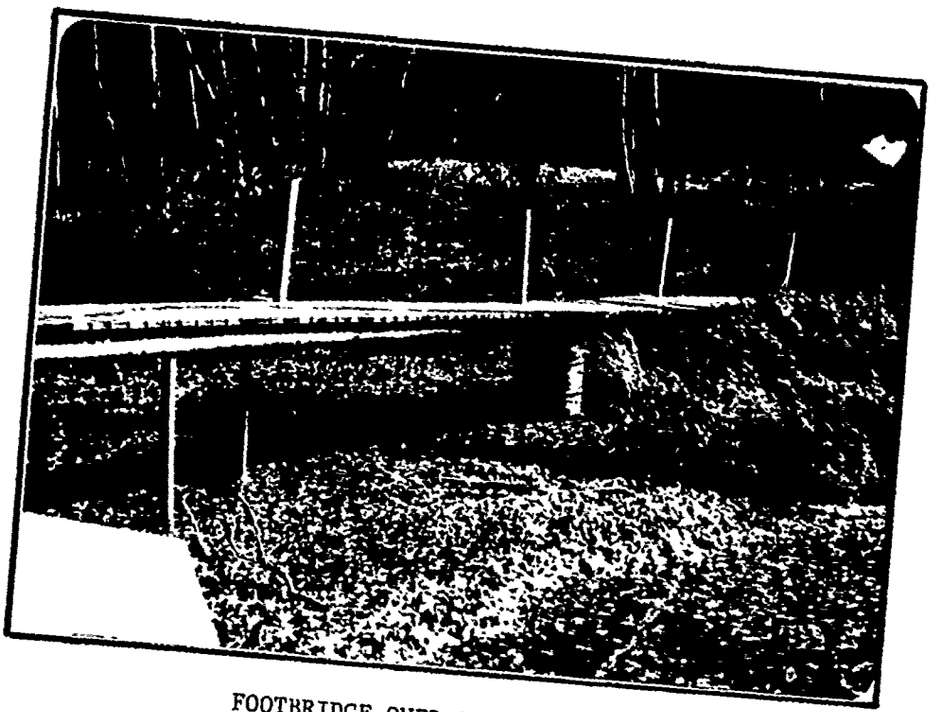
PIPE OUTLET WITH WOOD BLOCKING - NO. 4

DOWNSTREAM ACTIVE WEEPHOLE - NO. 5

PA-00091
Plate C-III



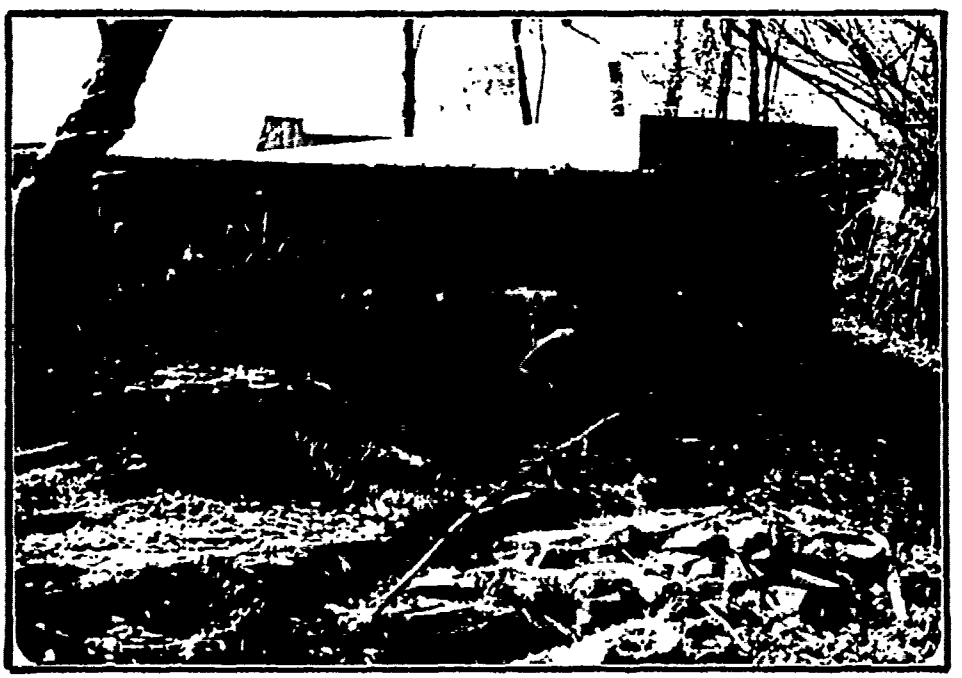
SPILLWAY FOREBAY - NO. 6



FOOTBRIDGE OVER SPILLWAY - NO. 7

PA-00091
Plate C-IV

LOOKING DOWNSTREAM IN SPILLWAY - NO. 8



LOOKING UPSTREAM TO 8-FOOT DROP
IN SPILLWAY DISCHARGE CHANNEL - NO. 9

PA-00091
Plate C-V

APPENDIX D

HYDROLOGY AND HYDRAULIC CALCULATIONS

SUMMARY DESCRIPTION
OF
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION

The hydrologic and hydraulic evaluation for this inspection report has employed computer techniques using the Corps of Engineers computer program identified as the Flood Hydrograph Package (HEC-1) Dam Safety Version.

The program has been designed to enable the user to perform two basic types of hydrologic analyses: (1) the evaluation of the overtopping potential of the dam, and (2) the capability to estimate the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. A brief summary of the computation procedures typically used in the dam overtopping analysis is shown below.

- Development of an inflow hydrograph to the reservoir.
- Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would overtop the dam.
- Routing of the outflow hydrograph(s) of the reservoir to desired downstream locations. The results provide the peak discharge and maximum stage of each routed hydrograph at the outlet of the reach.

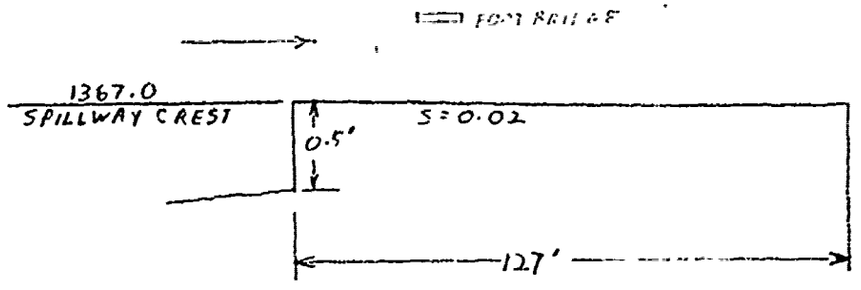
The output data provided by this program permits the comparison of downstream conditions just prior to a breach failure with that after a breach failure and the determination as to whether or not there is a significant increase in the hazard to loss of life as a result of such a failure.

The results of the studies conducted for this report are presented in Section 5.

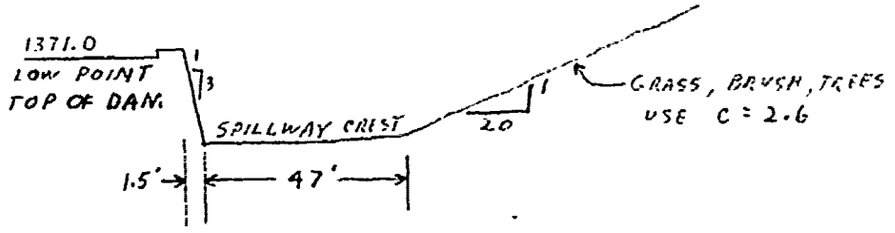
For detailed information regarding this program refer to the Users Manual for the Flood Hydrograph Package (HEC-1) Dam Safety Version prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

BY RLS DATE 11/19/79 **BERGER ASSOCIATES** SHEET NO. 1 OF 1
CHKD. BY DATE PROJECT D-96[illegible]
SUBJECT LAKE LADORE

SPILLWAY RATING



BROAD CRESTED WEIR WITH INCLINED CREST $C = 2.9$ (ESTIMATED FROM KING'S HDBK.)

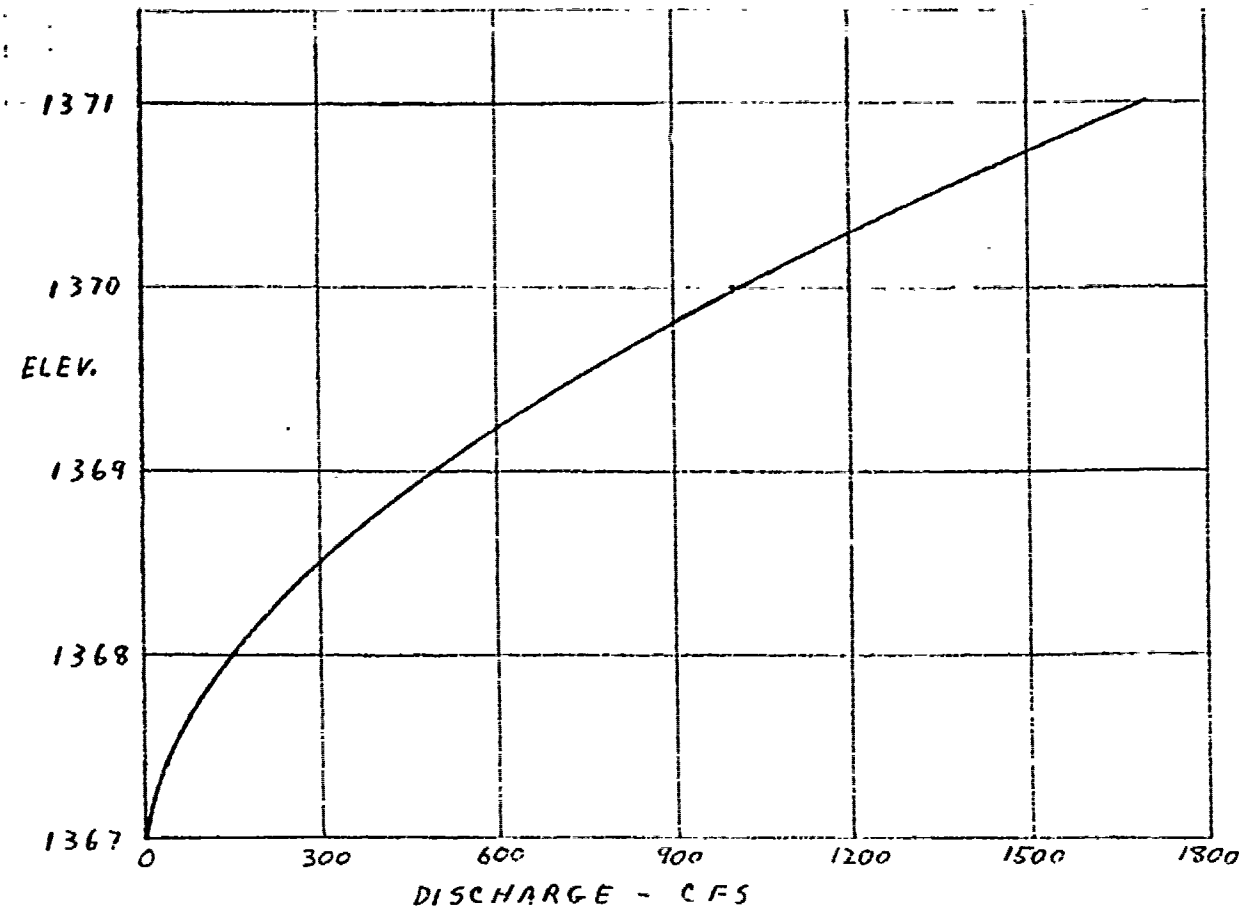


$$Q = C\,L\,H^{3/2}$$
$$= C_1 \times L_1 \times H_1^{3/2} + C_2 \times L_2 \times H_2^{3/2}$$

$C_1 = 2.9$
$H_1 = 1371 - 1367 = 4'$
$L_1 = 47 + (4/3)/2 = 47.7'$
$C_2 = 2.6$
$H_2 = (1371 - 1367)/2 = 2'$
$L_2 = 4 \times 20 = 80'$

$$Q = 2.9 \times 47.7 \times (4)^{1.5} + 2.6 \times 80 \times (2)^{1.5}$$
$$= 1106 + 588$$
$$= 1694 \text{ CFS}$$

SPILLWAY RATING CURVE



MAXIMUM KNOWN FLOOD AT DAMSITE

IT WAS REPORTED THAT THE MAXIMUM KNOWN FLOOD AT THE LAKE LADORE DAM CAUSED THE WATER LEVEL IN THE LAKE TO REACH AN ELEVATION 8" ABOVE THE SPILLWAY CREST.

$$Q = C_1 L_1 H_1^{3/2} + C_2 L_2 H_2^{3/2}$$

$C_1 = 2.9$ $\quad C_2 = 2.6$

$L_1 = 47 + \left((5/12)/3\right)/2 = 47.1$ $\quad L_2 = 5/12 \times 32 = 13.3'$

$H_1 = 5/12'$ $\quad H_2 = (5/12)/2 \quad 1/12'$

$Q = 2.9 \times 47.1 \times (5/12)^{1.5} + 2.6 \times 13.3 \times (1/12)^{1.5} = 81$ CFS

BY RLS DATE 11/20/79 **BERGER ASSOCIATES** SHEET NO. 3 OF
CHKD. BY DATE PROJECT D91-69
SUBJECT LAKE LADORE

DISCHARGE THROUGH OUTLET WORKS

OUTLET CONDUIT ASSUMED TO BE 18" C.I. THROUGH EMBANKMENT

LENGTH = APPROXIMATELY 133'

APPROXIMATE UPSTREAM CENTER LINE ELEV. = 1354

$$Q = C A \sqrt{2gH} \qquad C = 0.6$$

AT NORMAL POOL LEVEL – 1367

$H = 1367 - 1354 = 13'$

$$Q = 0.6 \times \pi \times ((1.5)^2/4) \times (2 \times 32.2 \times 13)^{0.5}$$

$= 30$ CFS

AT LOW POOL LEVEL – 1356

$H = 1356 - 1354 = 2'$

$$Q = 0.6 \times \pi \times ((1.5)^2/4) \times (2 \times 32.2 \times 2)^{0.5}$$

$= 12$ CFS

BY... DATE 11/20/79 | BERGER ASSOCIATES | SHEET NO. 4 OF.
CHKD. BY... DATE | PROJECT D966
SUBJECT LAKE LADORE

EMBANKMENT RATING

$Q = C L H^{3/2}$

AT ELEV 1371.2

$2.7 \times 12 \times (.1)^{1.5} = 1$ CFS

AT ELEV 1371.3

$2.7 \times 19 \times (.15)^{1.5} = 3$
$2.7 \times 232 \times (.1)^{1.5} = 20$
$2.7 \times 100 \times (.05)^{1.5} = 3$ $\Sigma = 26$ CFS

AT ELEV 1371.5

$2.7 \times 31 \times (.25)^{1.5} = 10.$
$2.7 \times 232 \times (.3)^{1.5} = 103$
$2.7 \times 100 \times (.25)^{1.5} = 34$ $\Sigma = 147$ CFS

AT ELEV 1372

$2.7 \times 37 \times (.7)^{1.5} = 59$
$2.7 \times 232 \times (.8)^{1.5} = 448$
$2.7 \times 100 \times (.75)^{1.5} = 175$
$2.7 \times 1 \times (.2)^{1.5} = -$ $\Sigma = 682$ CFS

AT ELEV 1372.5

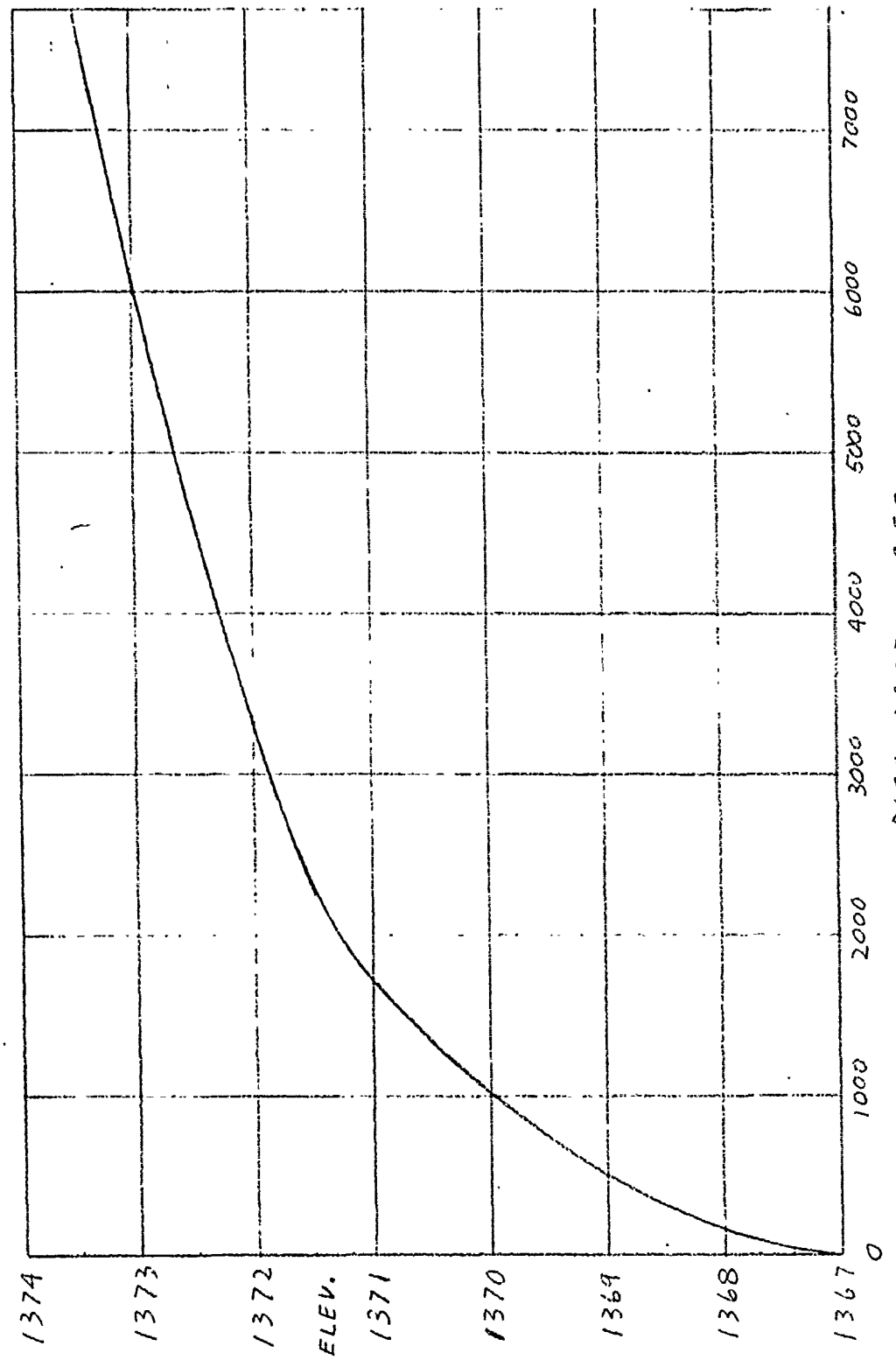
$2.7 \times 37 \times (1.2)^{1.5} = 131$
$2.7 \times 232 \times (1.3)^{1.5} = 928$
$2.7 \times 100 \times (1.25)^{1.5} = 377$
$2.7 \times 3 \times (.45)^{1.5} = 2$ $\Sigma = 1438$ CFS

AT ELEV 1373.5

$2.7 \times 37 \times (2.2)^{1.5} = 326$
$2.7 \times 232 \times (2.3)^{1.5} = 2185$
$2.7 \times 100 \times (2.25)^{1.5} = 911$
$27 \times 7 \times (.85)^{1.5} = 14$ $\Sigma = 3436$ CFS

BY RLS DATE 11/20/29 **BERGER ASSOCIATES** SHEET NO. 5 OF
CHKD. BY DATE PROJECT D9650
SUBJECT LAKE LADORE

DISCHARGE RATING CURVE



BY BLS DATE 11/20/79 BERGER ASSOCIATES SHEET NO. 6 OF 7
CHKD. BY DATE PROJECT 2.96-50
SUBJECT LAKE LADORE

SIZE CLASSIFICATION

MAXIMUM STORAGE = 2718 ACRE-FEET
MAXIMUM HEIGHT = 28 FEET
SIZE CLASSIFICATION IS "INTERMEDIATE"

HAZARD CLASSIFICATION

SEVERAL HOUSES AND KEEN POND DAM LOCATED DOWNSTREAM

USE "HIGH"

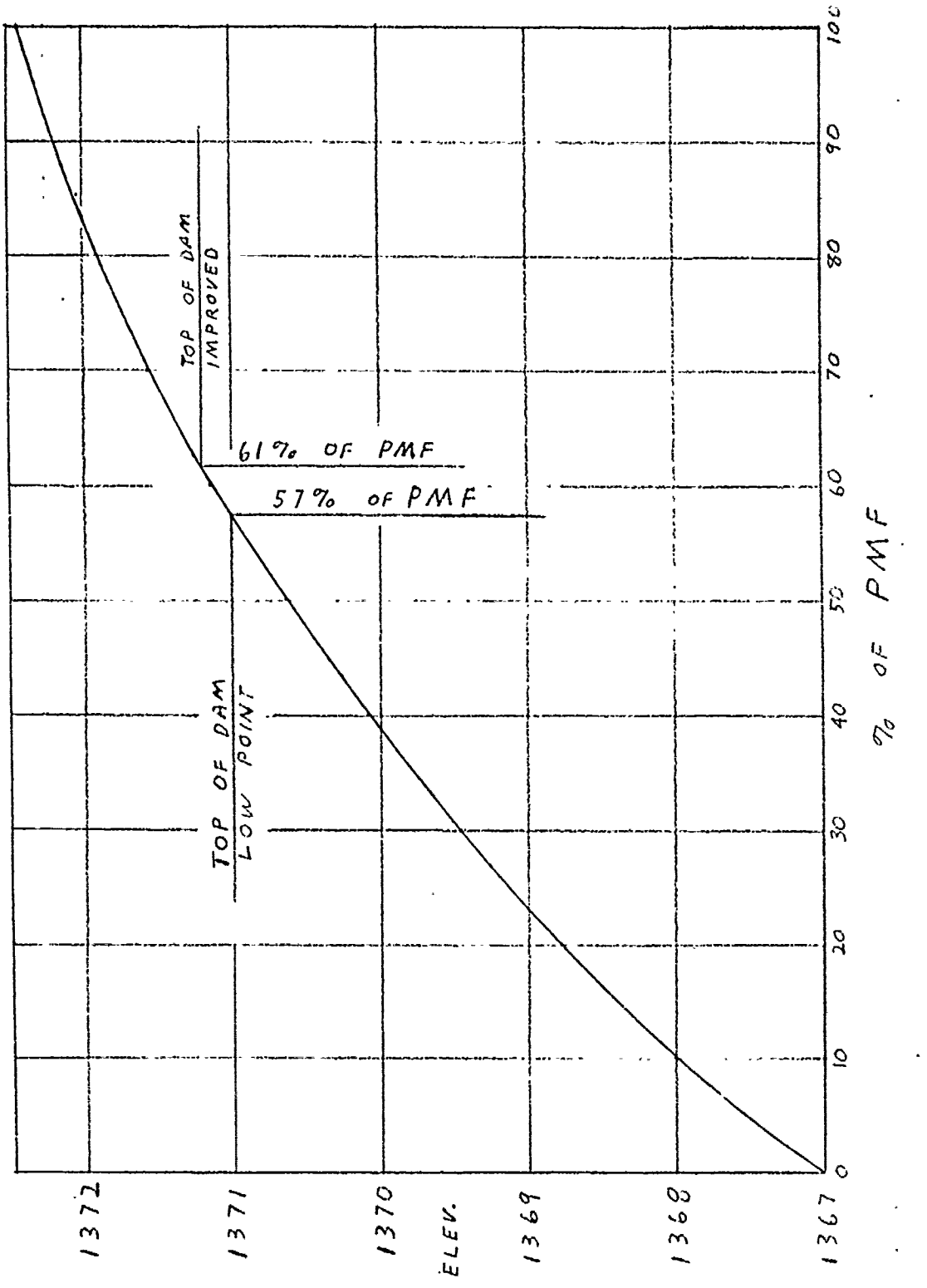
RECOMMENDED SPILLWAY DESIGN FLOOD

THE ABOVE CLASSIFICATIONS INDICATE USE OF AN SDF EQUAL TO THE PROBABLE MAXIMUM FLOOD.

BY RLS DATE 11/26/79 **BERGER ASSOCIATES** SHEET NO. 7 OF

CHKD. BY DATE PROJECT D9650

SUBJECT LAKE LADORE



HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: LAKE LADORE RIVER BASIN: DELAWARE

PROBABLE MAXIMUM PRECIPITATION (PMP) = 21.3 INCHES/24 HOURS[1]

(FOR FOOTNOTES SEE NEXT PAGE)

STATION		1	2	3	4
STATION DESCRIPTION		Lake Ladore	Lake Ladore Dam		
DRAINAGE AREA (SQUARE MILES)		3.37			
CUMULATIVE DRAINAGE AREA (SQUARE MILE)		3.37	3.37		
ADJUSTMENT OF PMP FOR DRAINAGE AREA (%)[2]	6 HOURS	111			
	12 HOURS	123			
	24 HOURS	133			
	48 HOURS	142			
	72 HOURS	-			
SNYDER HYDROGRAPH PARAMETERS	ZONE[3]	1			
	C_p / C_t[4]	0.45/1.23			
	L (MILES)[5]	4.17			
	L_{ca} (MILES)[5]	1.88			
	$T_p = C_t (L \cdot L_{ca})^{0.3}$ (hours)	2.28			
SPILLWAY DATA	CREST LENGTH (FT.)		47		
	FREEBOARD (FT.)		4		
	DISCHARGE COEFFICIENT		2.9		
	EXPONENT		1.5		
	ELEVATION		1367		
AREA[6] (ACRES)	NORMAL POOL		261		
	ELEV. 1380		390		
	ELEV. -				
STORAGE (ACRE-FEET)	NORMAL POOL[7]		1605		
	ELEV. 1348.6[8]		0		
	ELEV. -[8]				
	ELEV -[8]				

(1) Hydrometeorological Report 33 (Figure 1), U.S. Army, Corps of Engineers, 1956.

(2) Hydrometeorological Report 33 (Figure 2), U.S. Army, Corps of Engineers, 1956.

(3) Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's Coefficients (C_p and C_t).

(4) Snyder's Coefficients.

(5) L = Length of longest water course from outlet to basin divide.
L_{ca} = Length of water course from outlet to point opposite the centroid of drainage area.

(6) Planimetered area encompased by contour upstream of dam.

(7) PennDER files.

(8) Computed by conic method.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1            A1   LAKE LADORE DAM   ****  VAN AUKEN CREEK
    2            A2       CANAAN TWP., WAYNE COUNTY, PA.
    3            A3    NDI # PA-00091     PA DER # 64-5
    4            B   300       0      15       0       0       0       0       0      -4       0
    5            B1    5
    6            J     1       9       1
    7            J1    1     .85      .7      .6      .5      .4      .3      .2      .1
    8            K             1                                               1
    9            K1                 INFLOW  HYDROGRAPH
   10            H     1       1    3.37
   11            P           21.3     111     123     133     142
   12            T                                                       1     .05
   13            W   2.28     .45
   14            X   -1.5     .05       2
   15            K     1       2                                         1
   16            K1                 RESERVOIR  ROUTING
   17            Y                                       1
   18            Y1    1                                                       1605      -1
   19            Y4 1367  1367.4  1367.7    1368    1369    1370    1371  1371.5    1372  1372.5
   20            Y41373.5
   21            Y5    0      36      81     155     491    1002    1694    2291    3311    4586
   22            Y5 7716
   23            $A    0     261     390
   24            $E1348.6    1367    1380
   25            $$ 1367
   26            $D 1371
   27            K    99
1                          PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                                RUNOFF HYDROGRAPH AT          1
                                ROUTE HYDROGRAPH TO           2
                                END OF NETWORK


1**********
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION   JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********

 RUN  DATE= 79/11/26.
      TIME= 07.47.38.


                    LAKE LADORE DAM   ****  VAN AUKEN CREEK
                    CANAAN TWP., WAYNE COUNTY, PA.
                    NDI # PA-00091     PA DER # 64-5

                                    JOB SPECIFICATION
                NQ     NHR    NMIN    IDAY     IHR    MIN    METRC    IPLT    IPRT    NSTAN
               300       0      15       0       0       0       0       0      -4       0
                                      JOPER     NWT   LROPT   TRACE
                                          5       0       0       0

                    MULTI-PLAN ANALYSES TO BE PERFORMED
```

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	MSTAN
300	0	15	0	0	0	0	0	-4	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1
RTIOS= 1.00 .85 .70 .60 .50 .40 .30 .20 .10

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISHOW	ISAME	LOCAL
1	1	3.37	0.00	3.37	0.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	21.30	111.00	123.00	133.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 2.28 CP= .45 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= .05 RTIOR= 2.00

UNIT HYDROGRAPH 81 END-OF-PERIOD ORDINATES, LAG= 2.30 HOURS, CP= .45 VOL= 1.00

14.	52.	106.	170.	240.	310.	368.	410.	436.	437.
416.	388.	361.	337.	[illegible].	293.	273.	255.	238.	221.
207.	193.	180.	167.	156.	146.	136.	127.	118.	110.
103.	96.	89.	93.	78.	72.	67.	63.	59.	55.
51.	48.	44.	41.	39.	36.	34.	31.	29.	27.
25.	24.	22.	21.	19.	18.	17.	16.	14.	14.
13.	12.	11.	10.	10.	9.	8.	8.	7.	7.
6.	6.	5.	5.	5.	4.	4.	4.	4.	3.
3.									

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM	24.20	21.81	2.39	188763.
	(615.)	(554.)	(61.)	(5345.17)

RESERVOIR ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	0	0	0	0

NSTPS	NSTDL	LAG	AMSNK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	1605.	-1

STAGE	1367.00	1367.40	1367.70	1368.00	1369.00	1370.00	1371.00	1371.50	1372.00	1372.50
	1373.50									
FLOW	0.00	36.00	81.00	155.00	471.00	1002.00	1694.00	2291.00	3311.00	4586.00
	7716.00									
SURFACE AREA=	0.	261.	390.							
CAPACITY=	0.	1691.	5884.							
ELEVATION=	1349.	1367.	1380.							

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
1367.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
1371.0	0.0	0.0	0.

PEAK OUTFLOW IS 4374. AT TIME 44.25 HOURS

PEAK OUTFLOW IS 3389. AT TIME 44.50 HOURS

PEAK OUTFLOW IS 2416. AT TIME 45.25 HOURS

PEAK OUTFLOW IS 1867. AT TIME 45.50 HOURS

PEAK OUTFLOW IS 1440. AT TIME 45.75 HOURS

PEAK OUTFLOW IS 1058. AT TIME 46.25 HOURS

PEAK OUTFLOW IS 726. AT TIME 46.50 HOURS

PEAK OUTFLOW IS 415. AT TIME 47.25 HOURS

PEAK OUTFLOW IS 156. AT TIME 48.25 HOURS

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 1.00	RATIO 2 .85	RATIO 3 .70	RATIO 4 .60	RATIO 5 .50	RATIO 6 .40	RATIO 7 .30	RATIO 8 .20	RATIO 9 .10
HYDROGRAPH AT	1	3.37	1	6030.	5126.	4221.	3618.	3015.	2412.	1809.	1206.	603.
	(	8.73)	(	170.76)(	145.15)(	119.53)(	102.46)(	85.38)(	68.30)(	51.23)(	34.15)(	17.08)
ROUTED TO	2	3.37	1	4374.	3389.	2416.	1867.	1440.	1058.	726.	415.	156.
	(	8.73)	(	123.85)(	95.96)(	68.41)(	52.86)(	40.76)(	29.95)(	20.56)(	11.75)(	4.43)

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

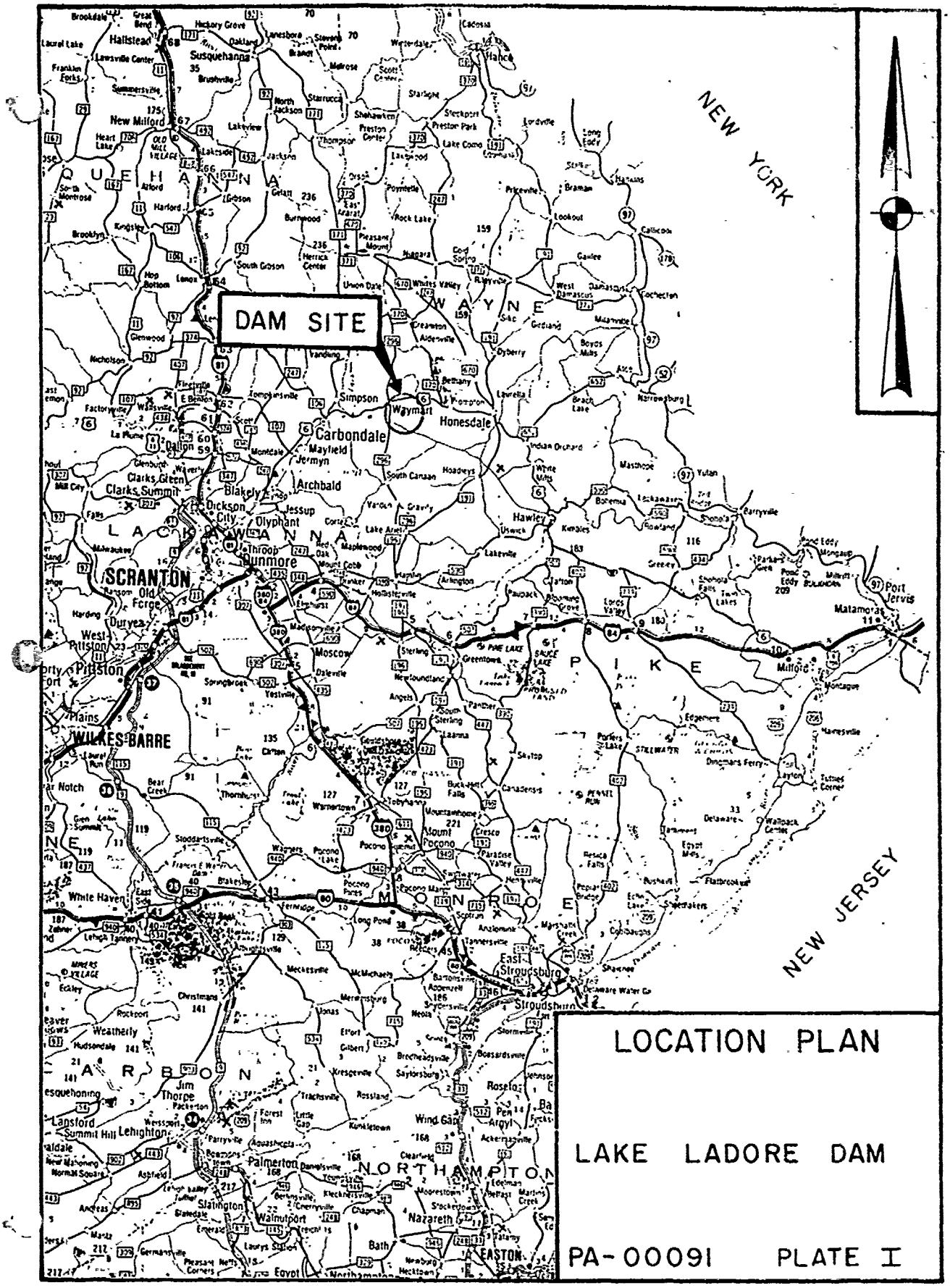
	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1367.01	1367.00	1371.00
STORAGE	1604.	1601.	2718.
OUTFLOW	1.	0.	1694.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	1372.42	1.42	3150.	4374.	9.00	44.25	0.00
.85	1372.03	1.03	3030.	3389.	7.75	44.50	0.00
.70	1371.56	.56	2887.	2416.	5.75	45.25	0.00
.60	1371.14	.14	2761.	1867.	3.00	45.50	0.00
.50	1370.63	0.00	2609.	1440.	0.00	45.75	0.00
.40	1370.08	0.00	2448.	1058.	0.00	46.25	0.00
.30	1369.46	0.00	2270.	726.	0.00	46.50	0.00
.20	1368.77	0.00	2078.	415.	0.00	47.25	0.00
.10	1368.00	0.00	1867.	156.	0.00	48.25	0.00

EOI ENCOUNTERED.
N>

APPENDIX E

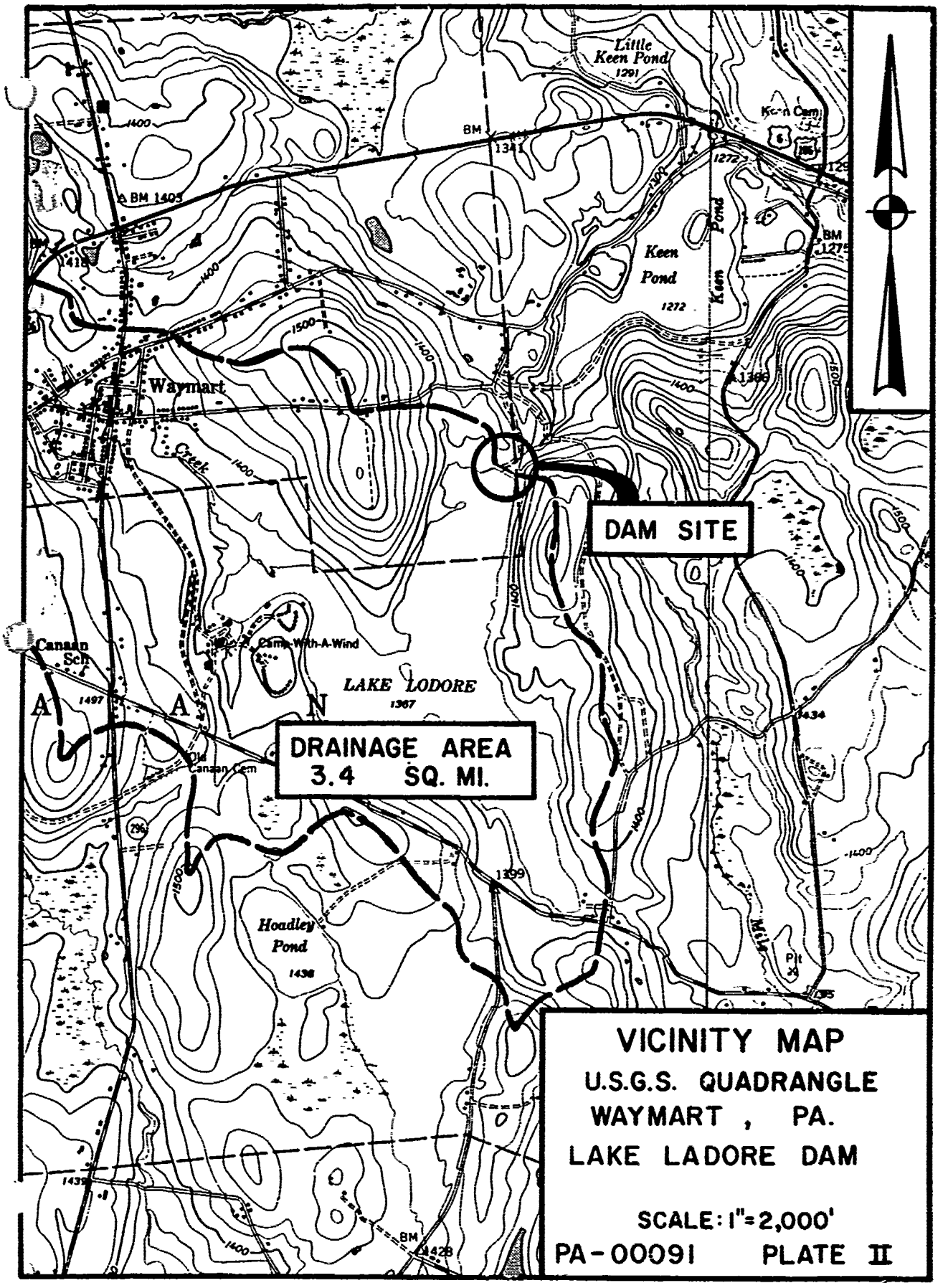
PLATES



LOCATION PLAN

LAKE LADORE DAM

PA-00091 PLATE I



VICINITY MAP

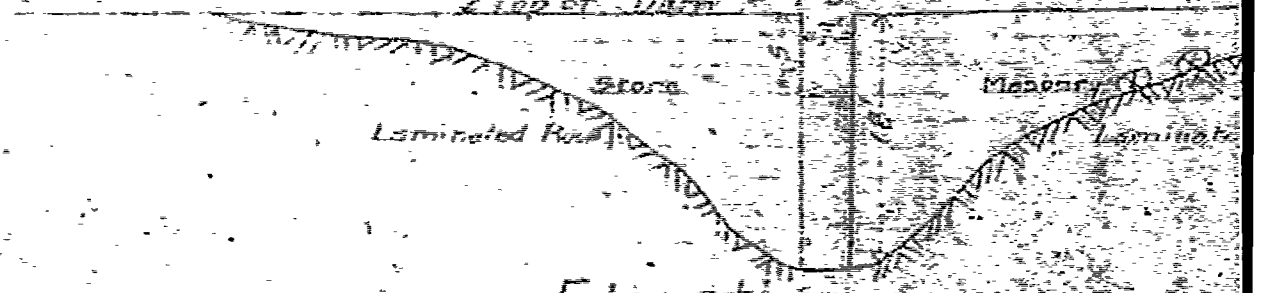
U.S.G.S. QUADRANGLE

WAYMART , PA.

LAKE LADORE DAM

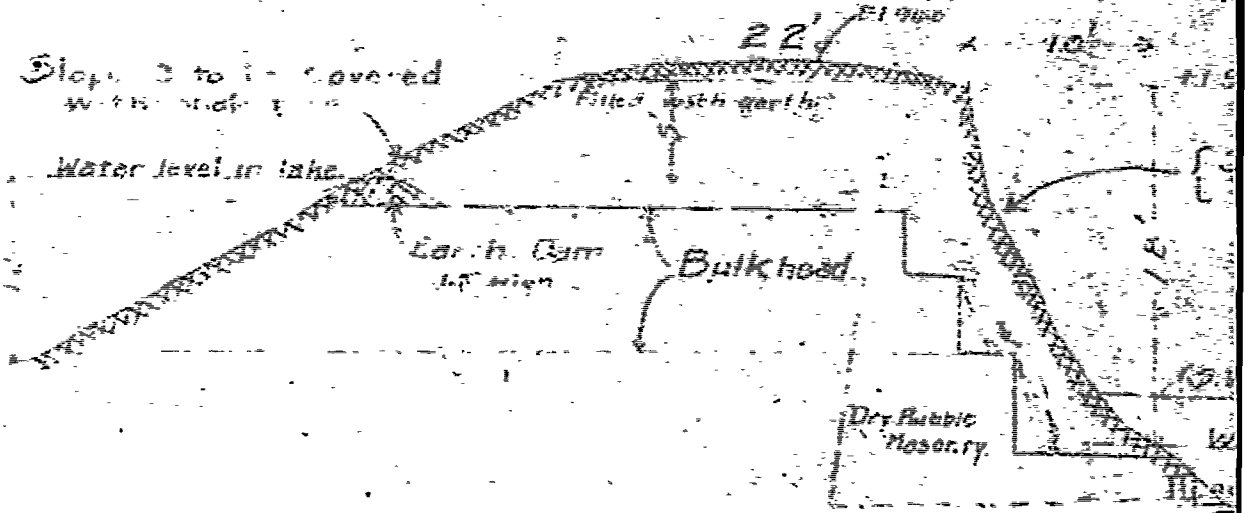
SCALE: 1"=2,000'

PA-00091 PLATE II



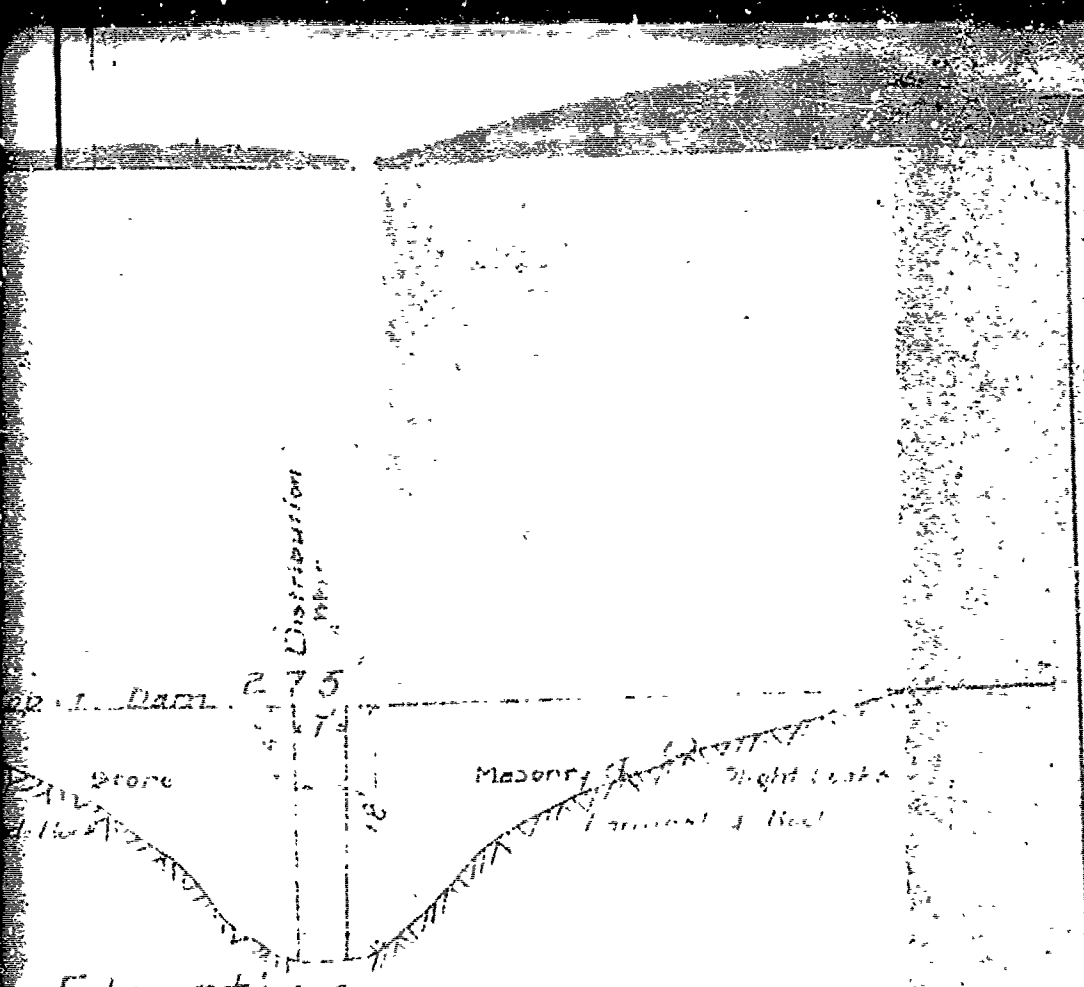
Elevation.

Dam at Lake Lado



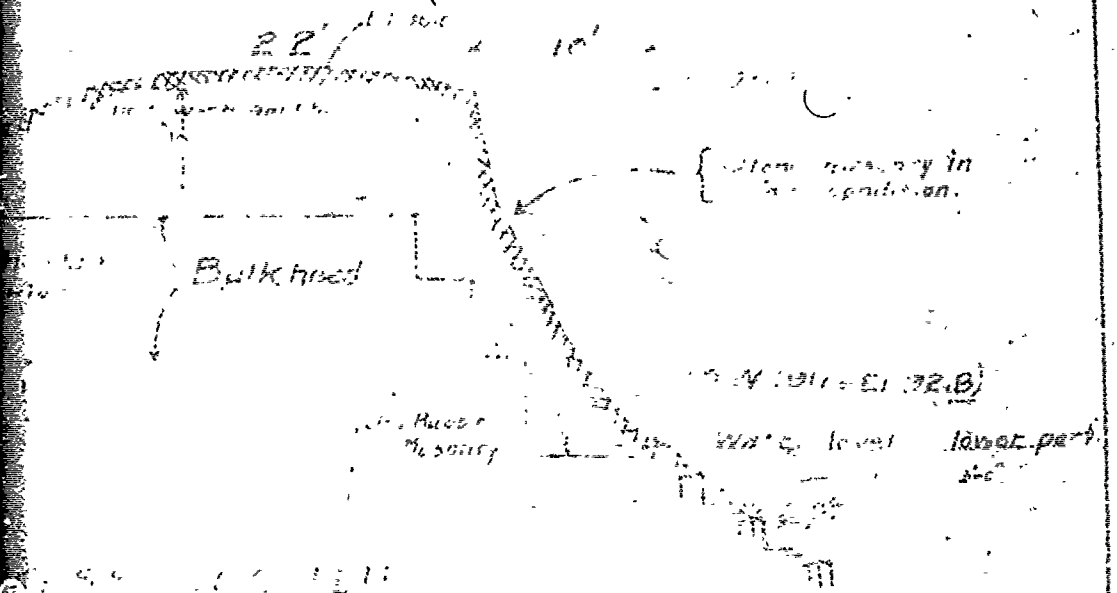
Cross-section

1



Elevation.

at Lake Ladore

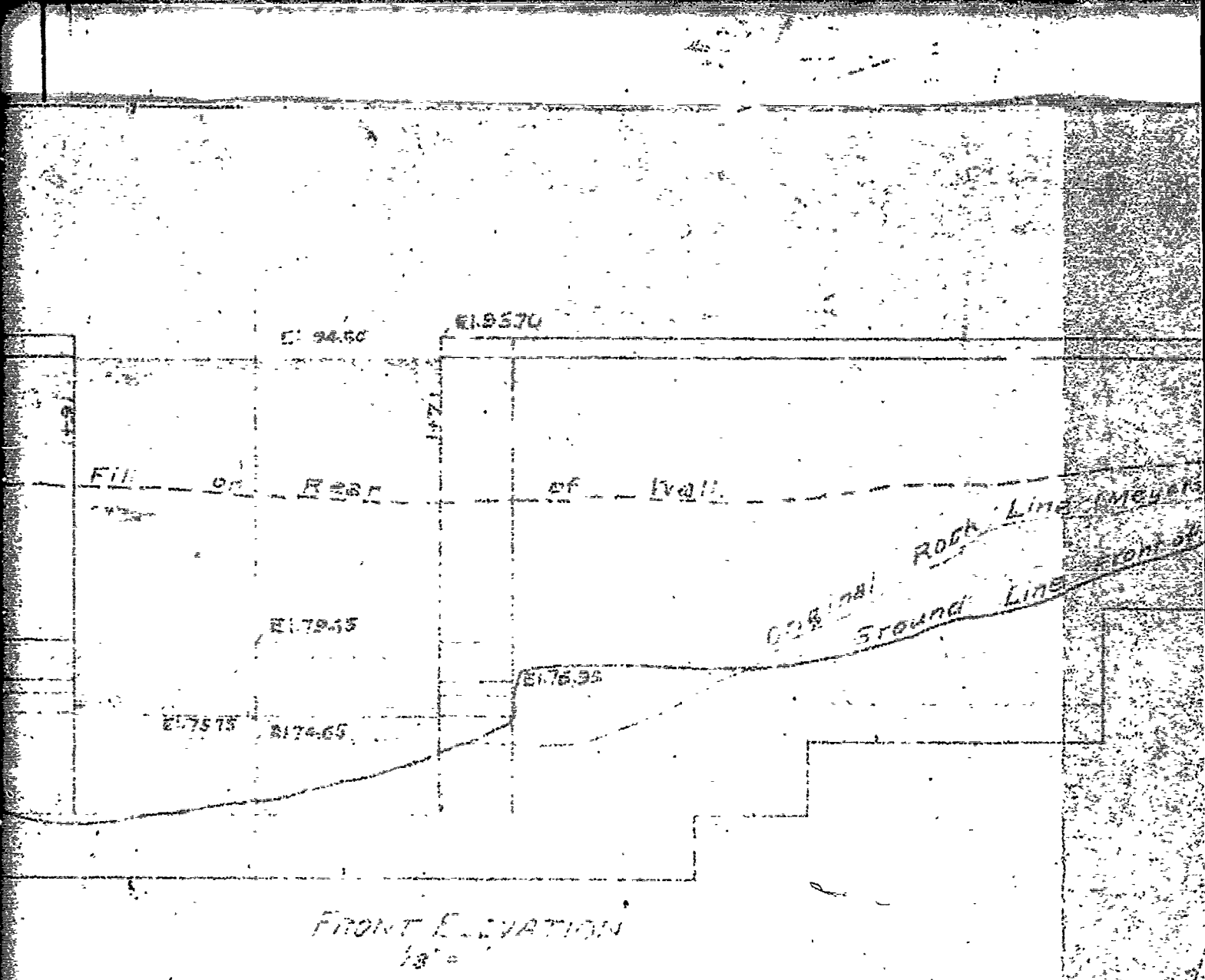


2

PA-00091
PLATE III

El 95.75

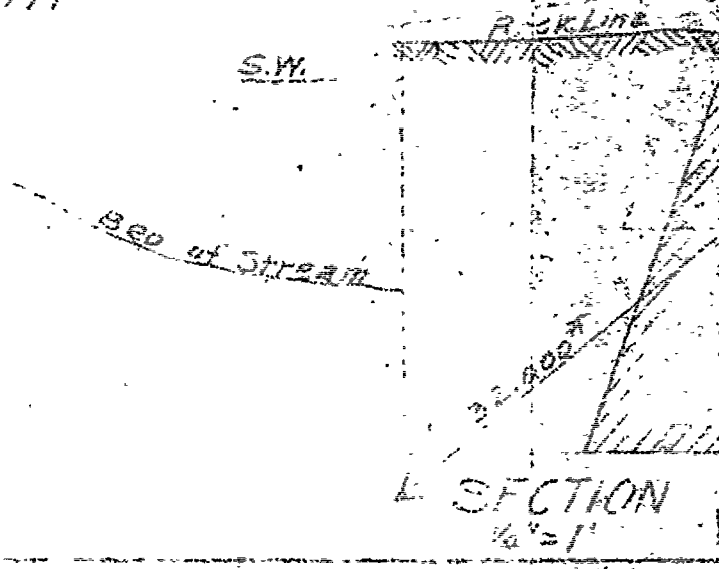
18" Outlet Pipe



FRONT ELEVATION
1/8" = 1'

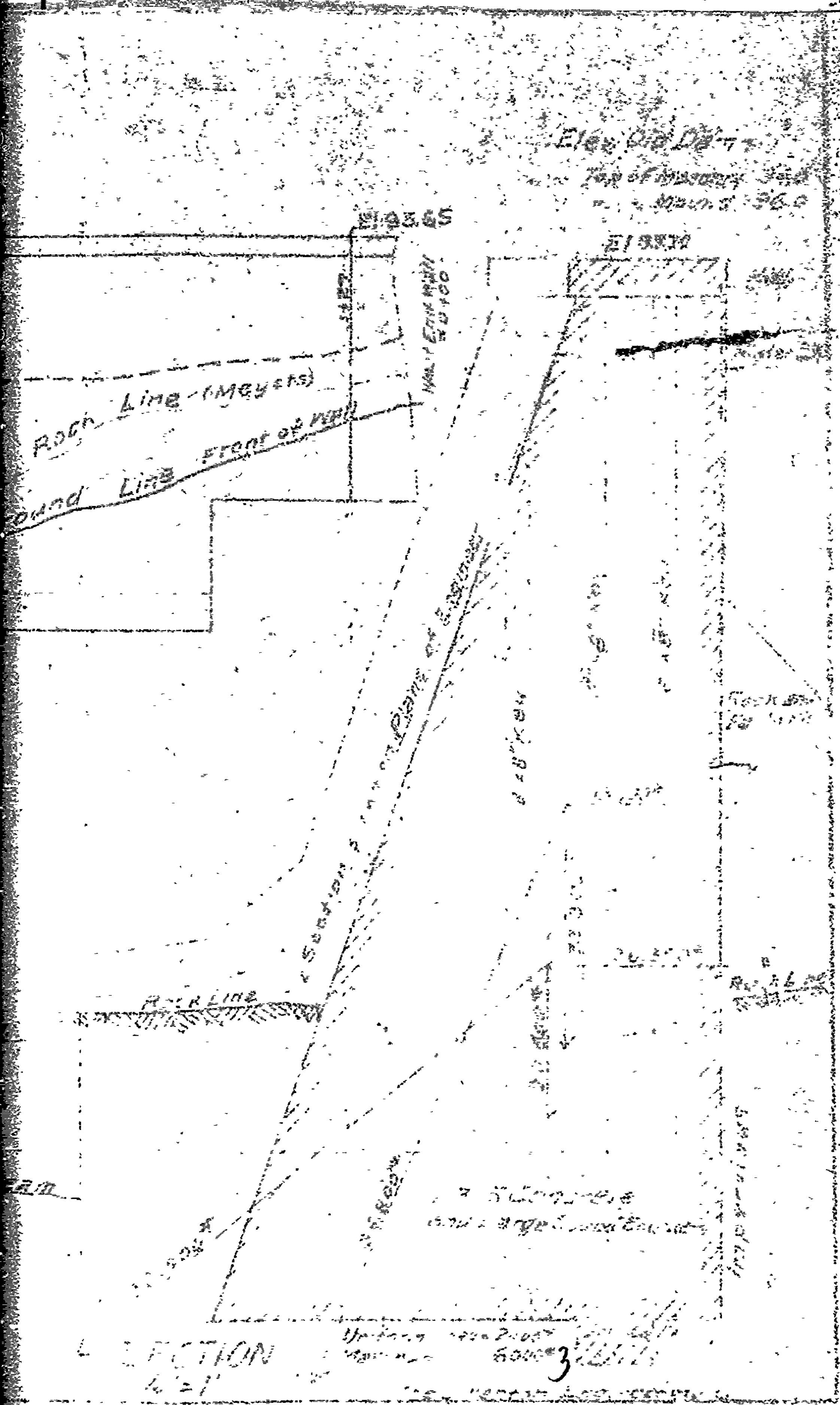
Rubble-Concrete Dam
AT LAKE LADORE,
Wayne Co, Pa.

Dec. 1911

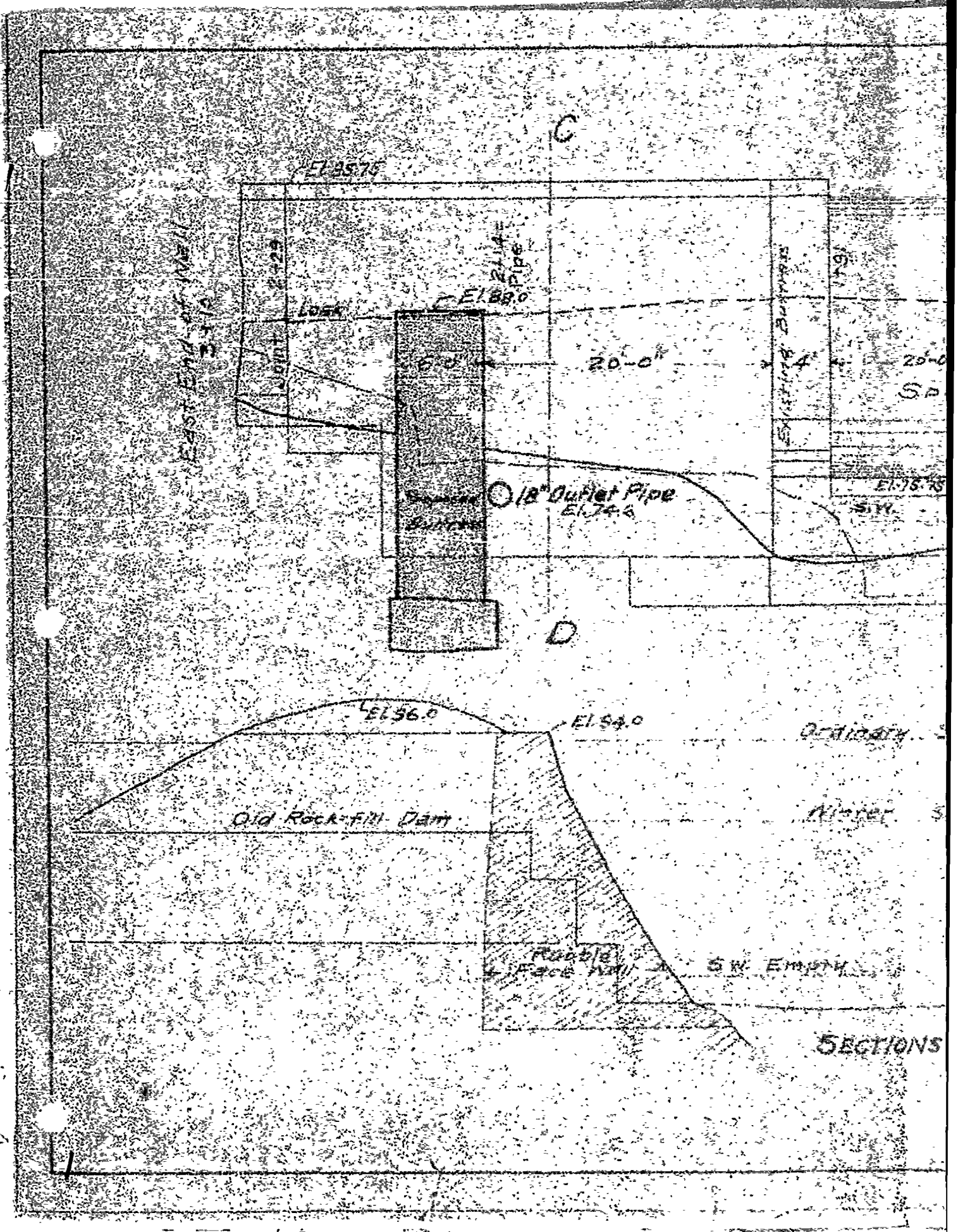


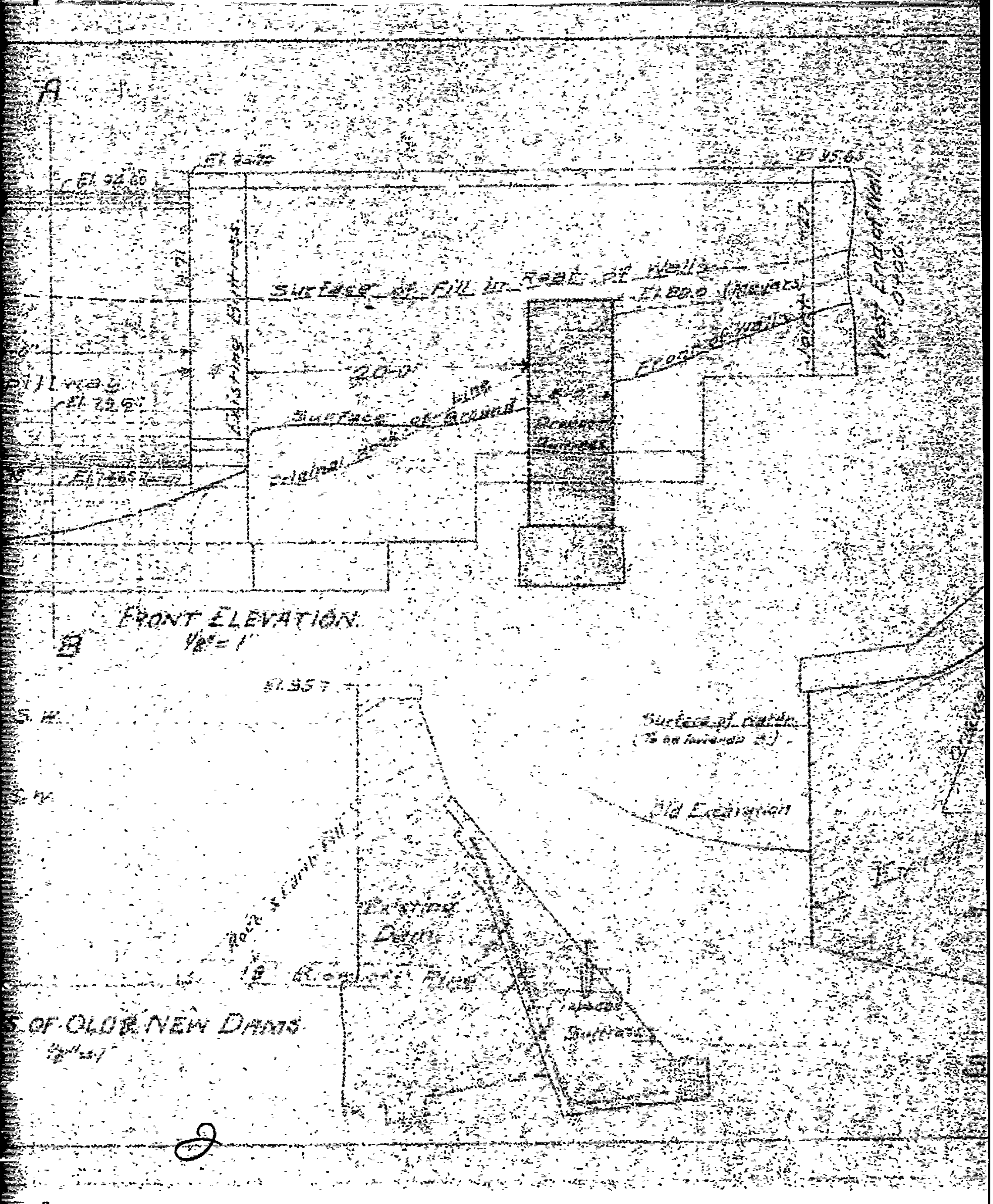
L SECTION
1/8" = 1'

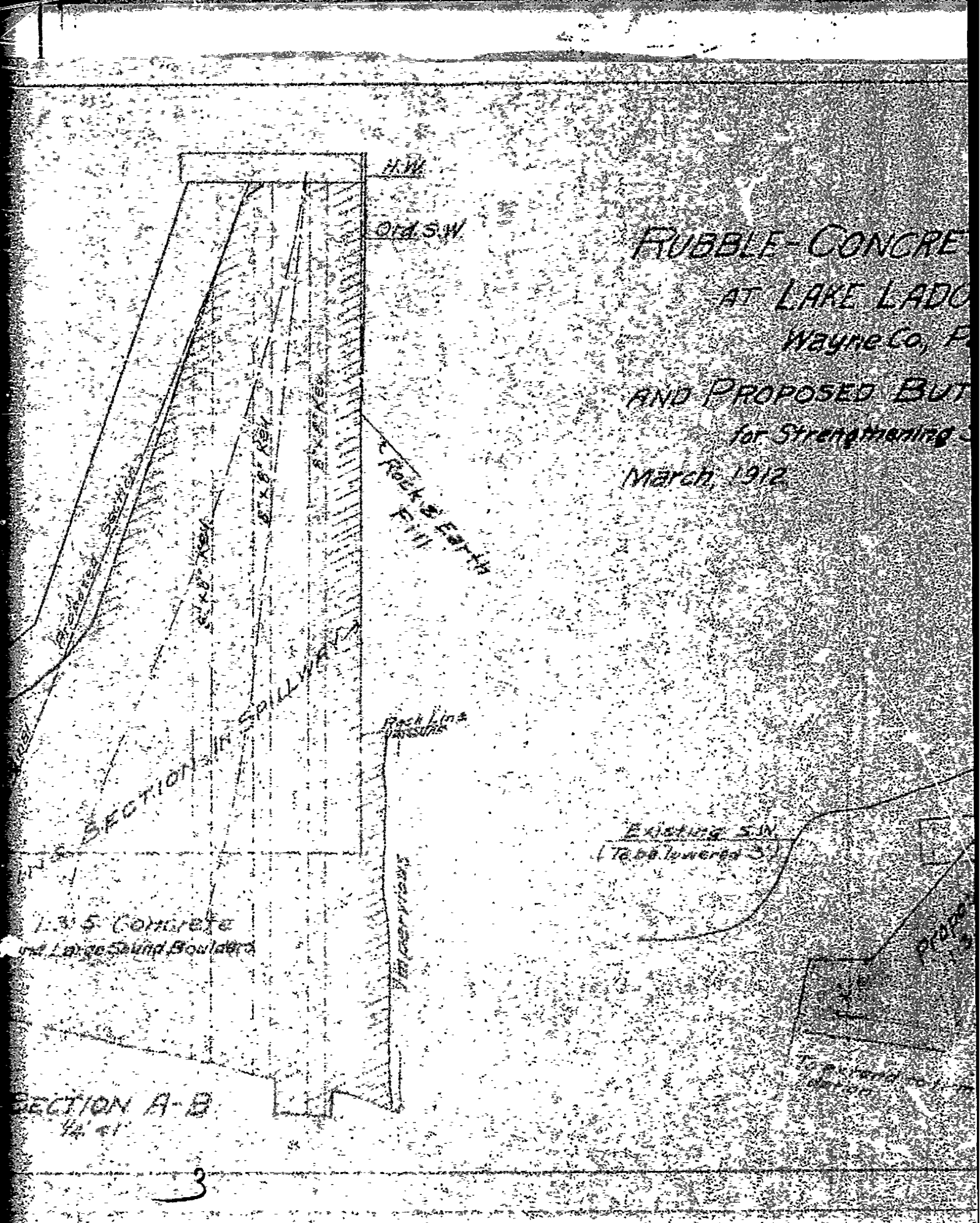
2



PA-00091
PLATE IV

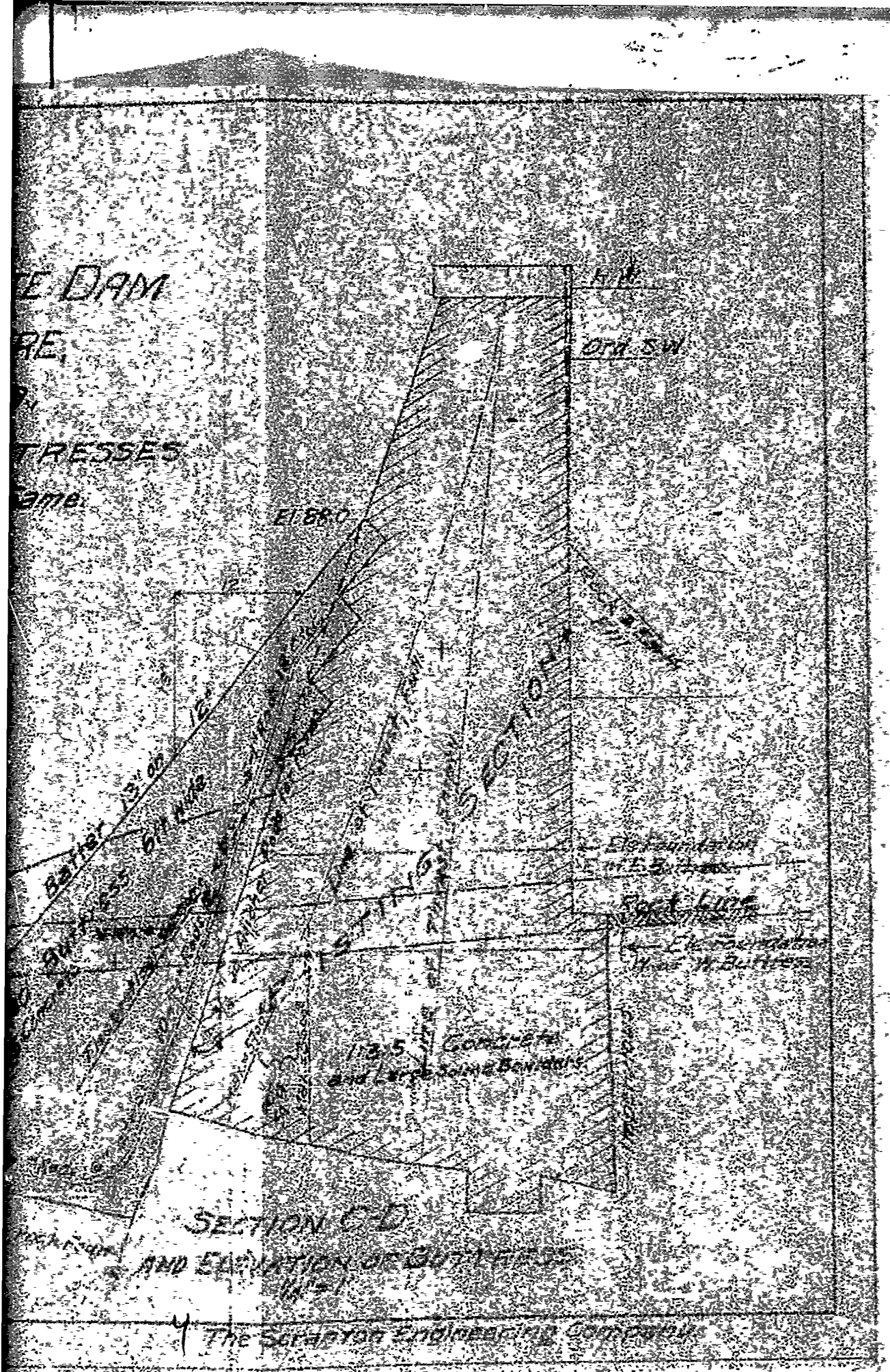

C
El 95.75
El 88.0
Lock
6'-0"
20'-0"
18" Outlet Pipe
El 74.6
Sluiceway
D
El 56.0
El 94.0
Old Rock-fill Dam
Rubble Face Wall
SW Empty
SECTIONS


A
El 94.66
El 95.65
Surface of Fill in Rear of Wall
Front of Wall
West End of Wall
Existing Buttress
20'-0"
Surface of Ground
Proposed Buttress
El 72.6
FRONT ELEVATION.
1/8"=1'
B
El 55.7
Surface of Water
Old Excavation
Existing Dam
Proposed Buttress
S OF OLD & NEW DAMS

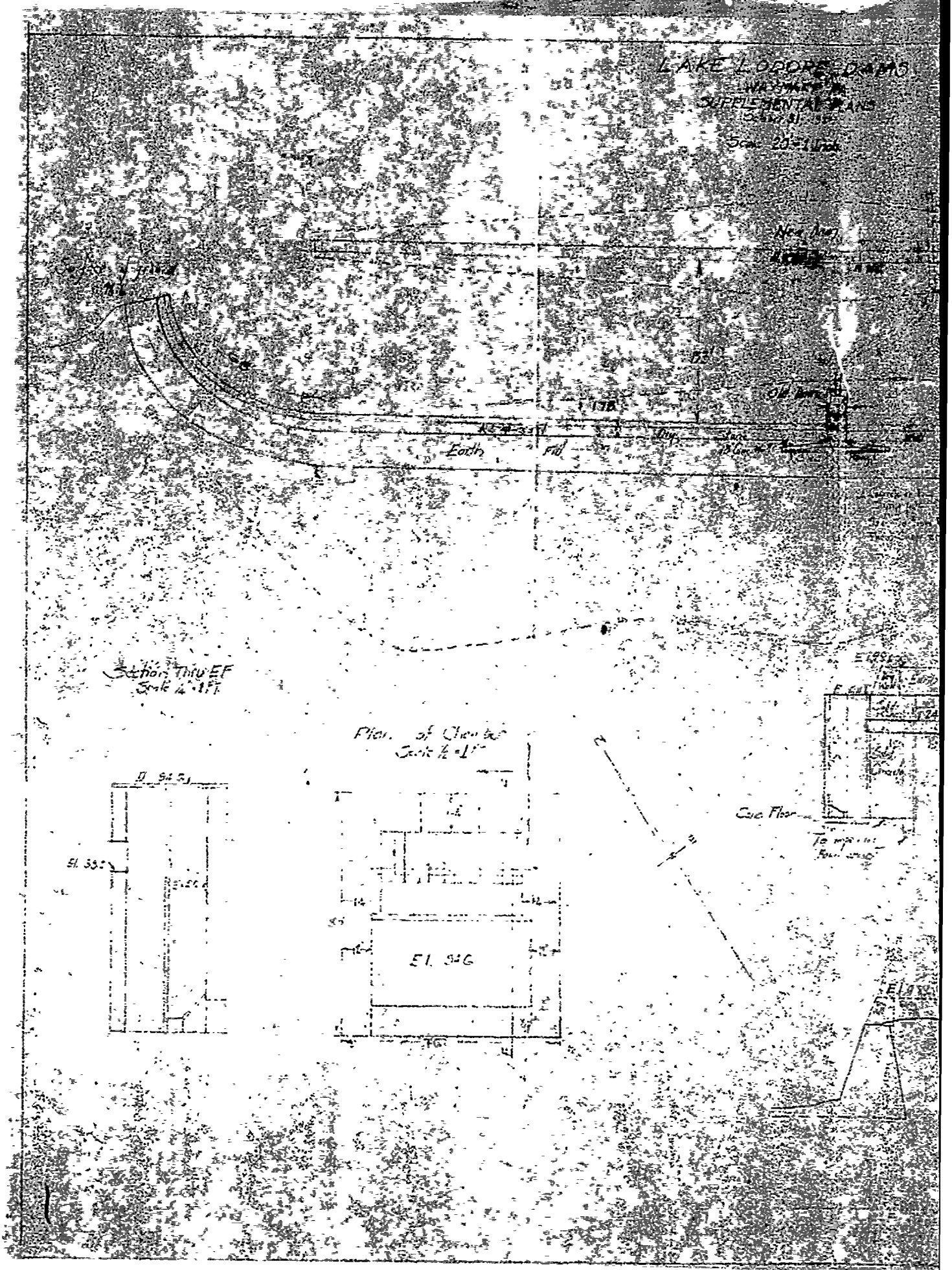


RUBBLE-CONCRE
AT LAKE LADO
Wayne Co, P
AND PROPOSED BUT
for Strengthening
March, 1912

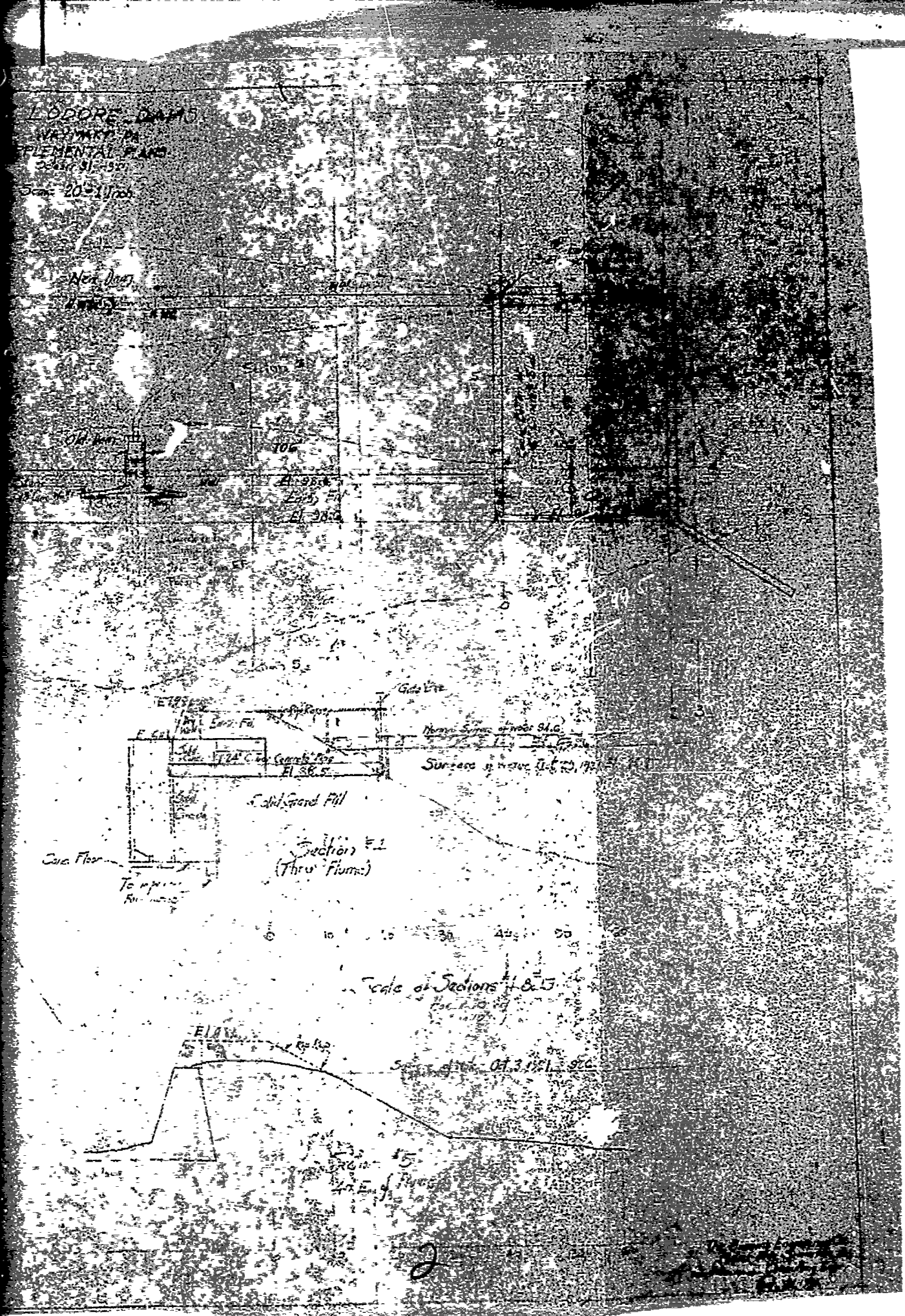
3



PA-00091
PLATE V


LAKE LODORE DAMS
SUPPLEMENTAL PLANS
Scale 1" = 100'
Scale 20' = 1 Inch
New Dam
Old Dam
Earth Fill
Dip
Section Thru EF
Scale 1" = 1'
Plan of Chamber
Scale 1/2" = 1'
El. 946
El. 946
Cue Floor

LODORE DAM
WAYNESBORO PA
SUPPLEMENTAL PLANS
Scale 20 = 1 Inch



PA-0009
PLATE V

LA

Approximate Bottom of Slope

0010

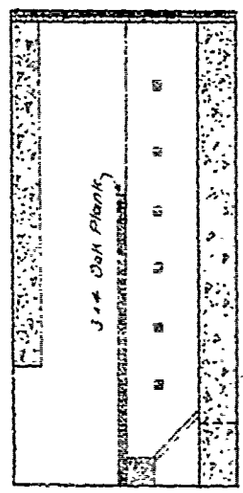
Approximate Bottom of Slope

Scale

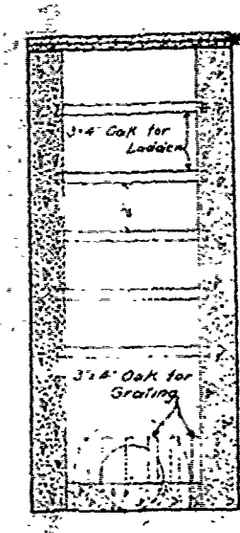
Approximate Bottom of Slope

Approximate Bottom of Slope

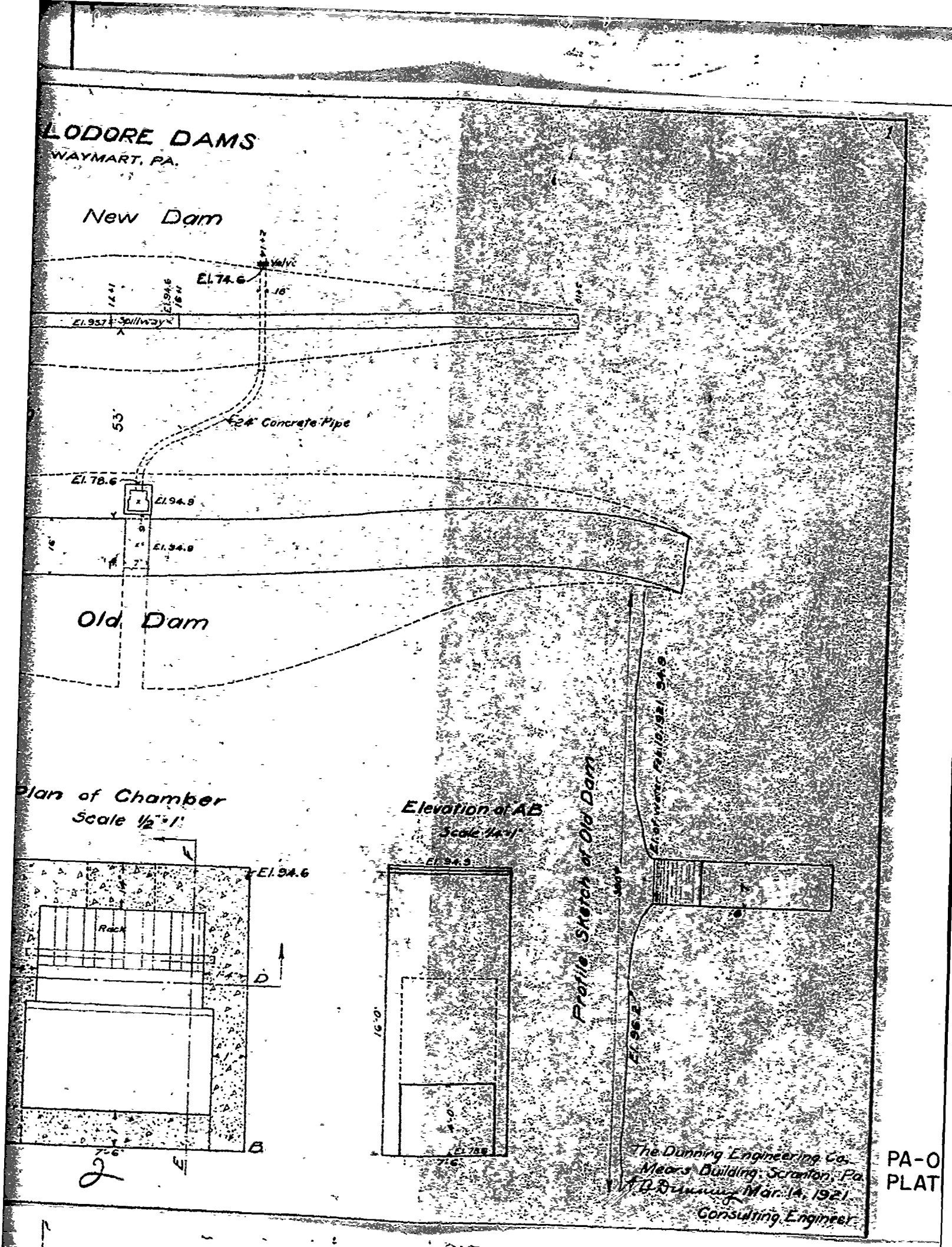
Section through 'EF'
Scale 1/4"=1'



Section through 'CD'
Scale 1/4"=1'



LODORE DAMS
WAYMART, PA.



The Dunning Engineering Co.
Mears Building, Scranton, Pa.
T. D. Dunning Mar. 14, 1921
Consulting Engineer.

PA-0
PLAT

Concrete in face of dam disintegrated and leaking as indicated, cracks to be filled and face of dam gunited

Cut off wall 2'6" wide 16'0" deep to be constructed

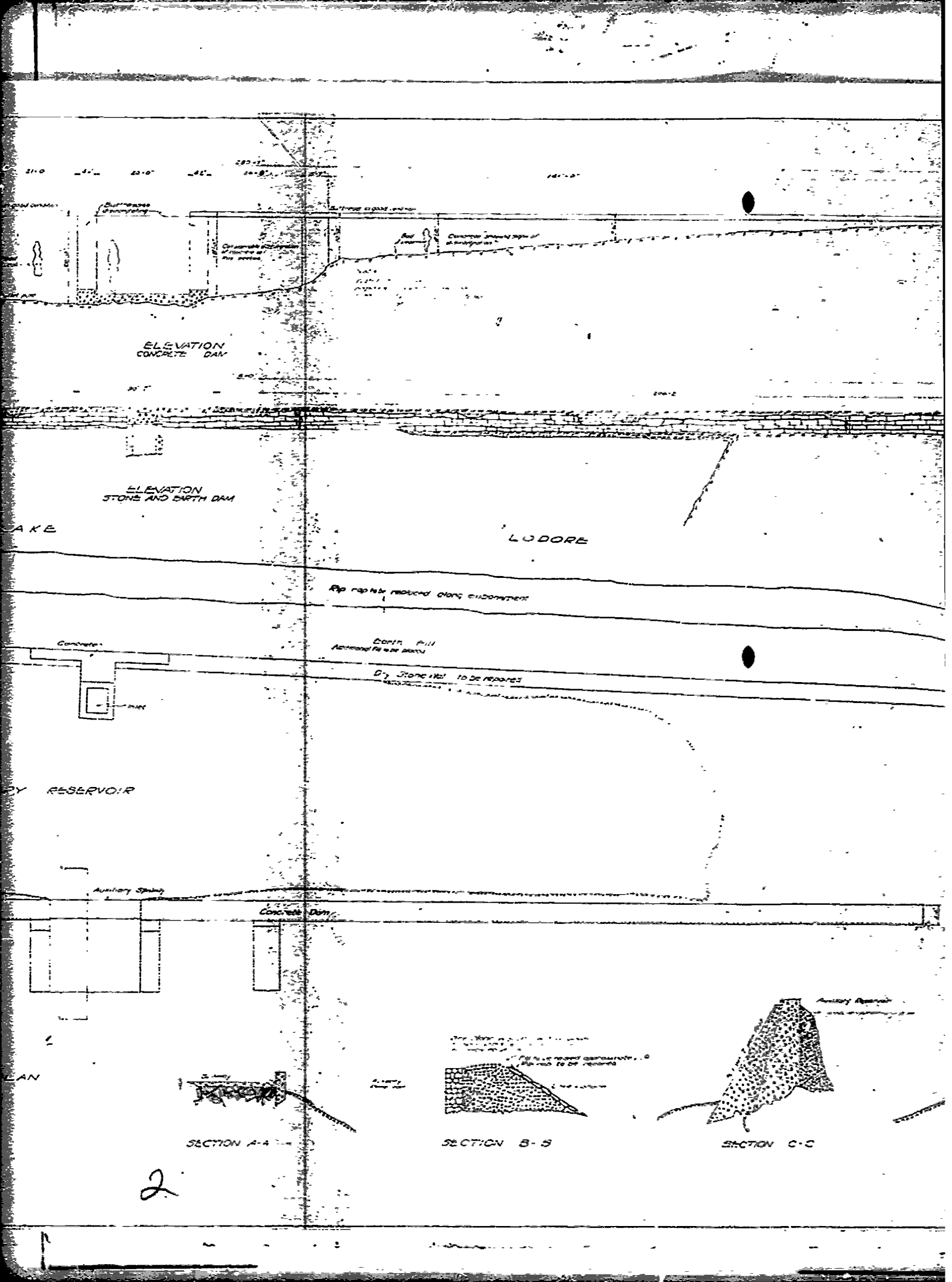
ELEVATION

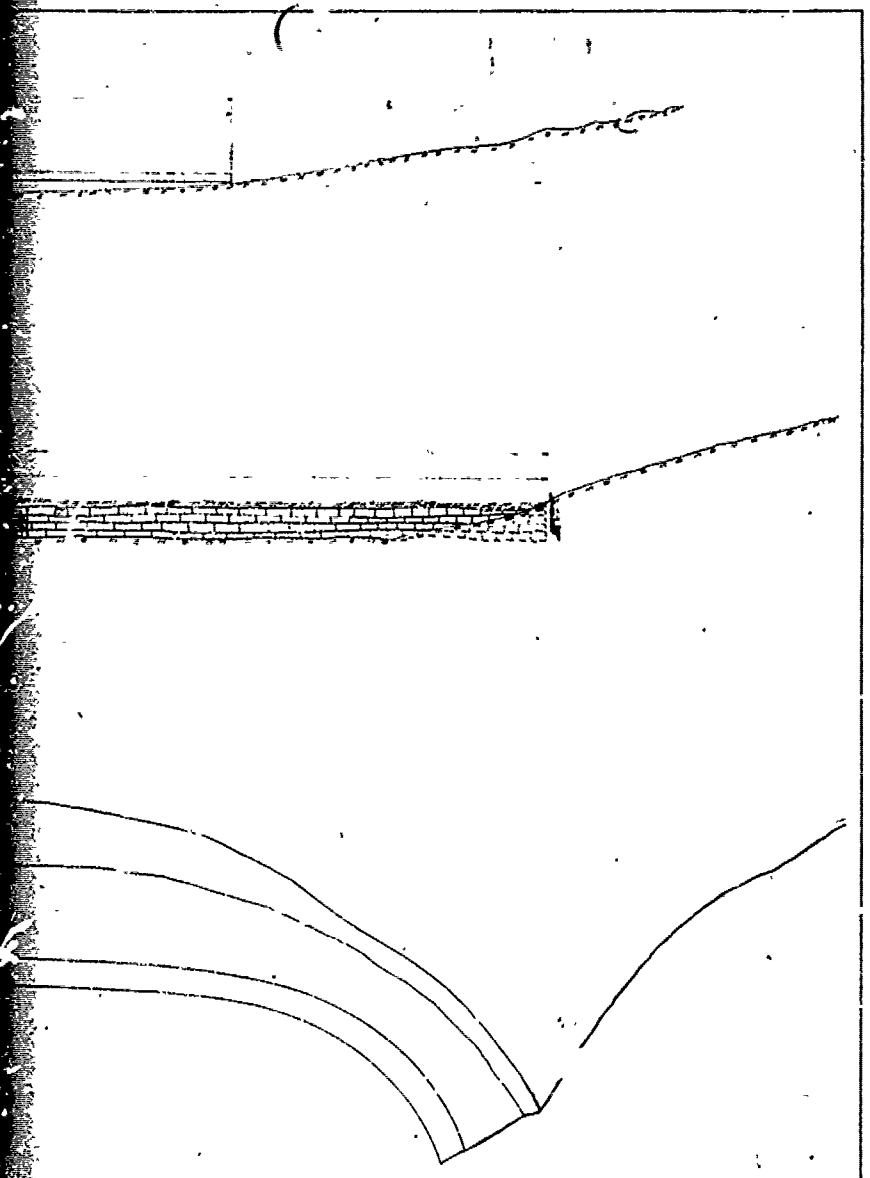
SPILLWAY

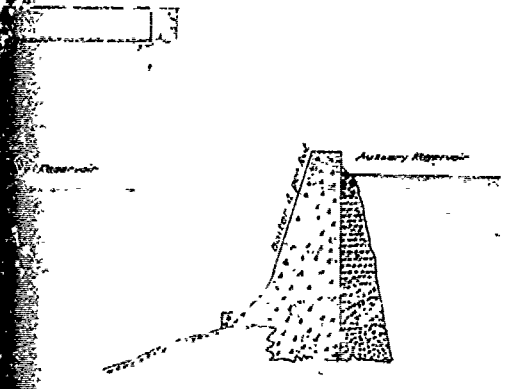
Concrete Apron to be repaired

FALLS

CREEK


ELEVATION
CONCRETE DAM
ELEVATION
STONE AND EARTH DAM
LODORE
Rip rap to be replaced along embankment
Earth Fill
Dry Stone Wall to be repaired
RESERVOIR
Auxiliary Spillway
Concrete Dam
SECTION A-A
SECTION B-B
SECTION C-C
2





SECTION D - D

3

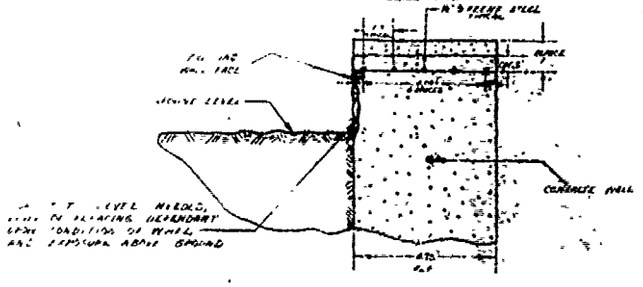
THE DELAWARE AND HUDSON R.R. CORPORATION
PENNSYLVANIA DIVISION VAL. SEC. 2C

REPAIRS TO DAM AT LAKE LODORE, PA.

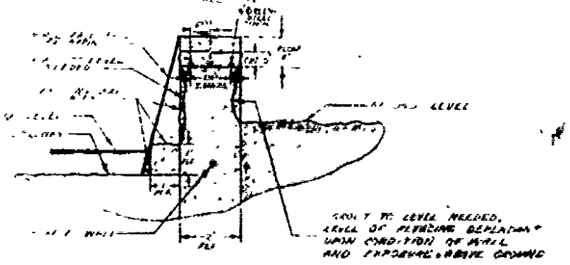
Office of Division Engineer Scale 1"=10'
Carbondale, Pa. December 29 1936
56 53

PA-00091
PLATE VIII

SECTION CC
TYPICAL
EXTERIOR WALL

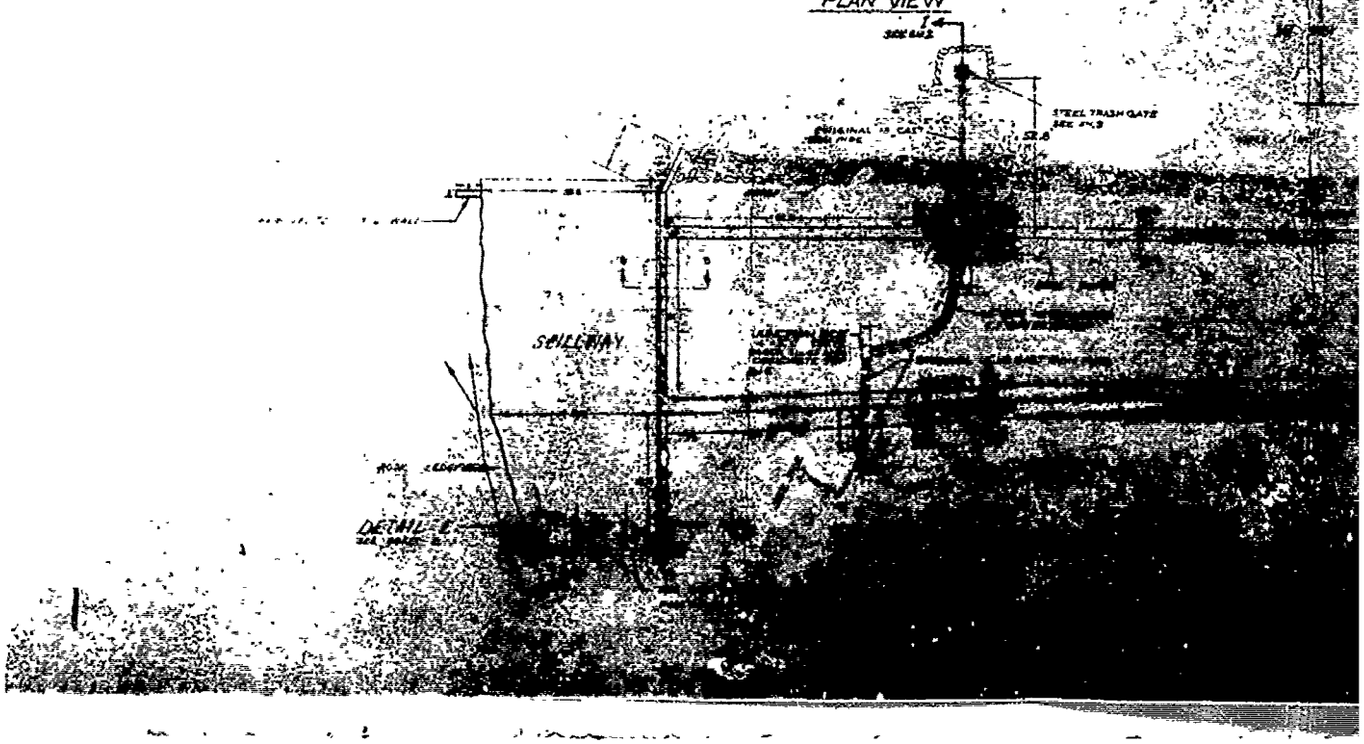


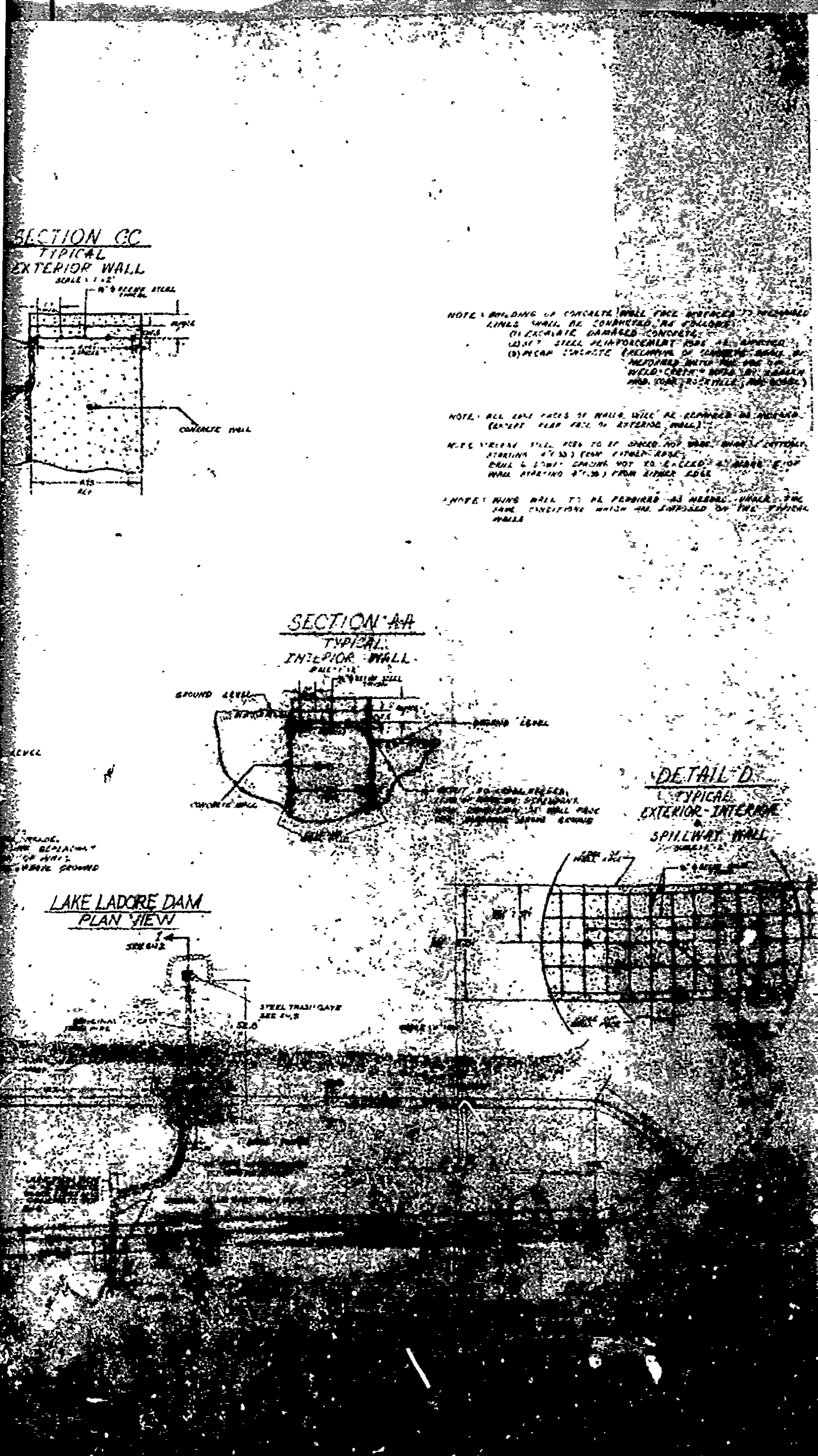
SECTION BB
TYPICAL
WALL



SECTION AA
TYPICAL
EXTERIOR WALL

LAKE LADORE DAM
PLAN VIEW

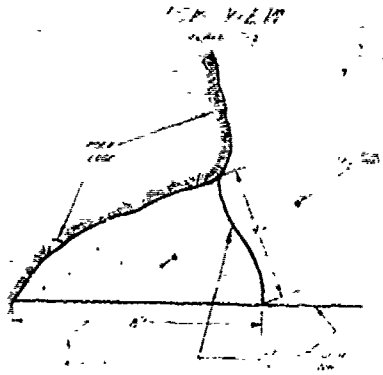


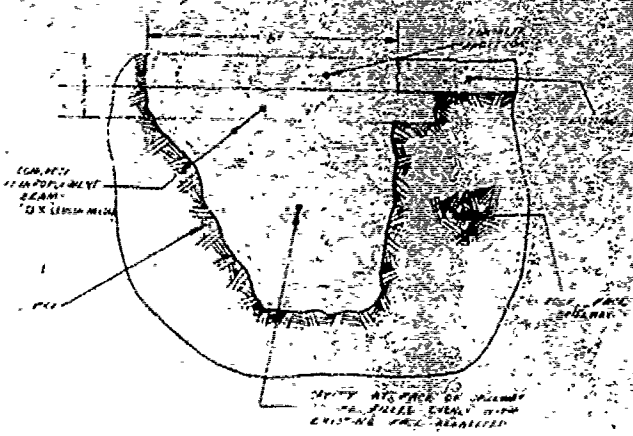


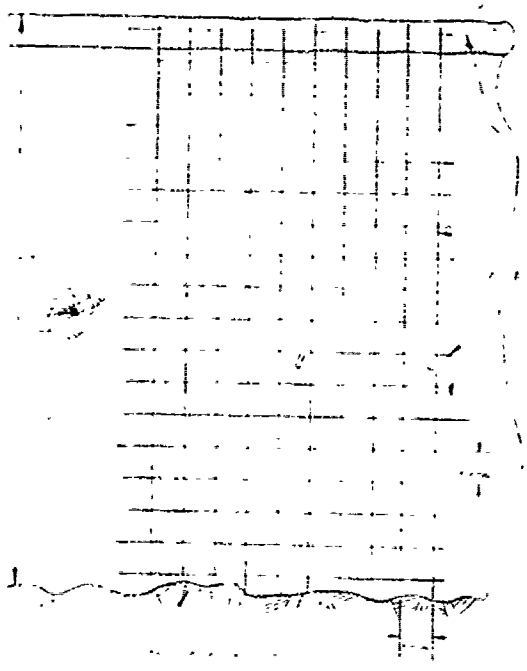
PA-00091
PLATE IX
2

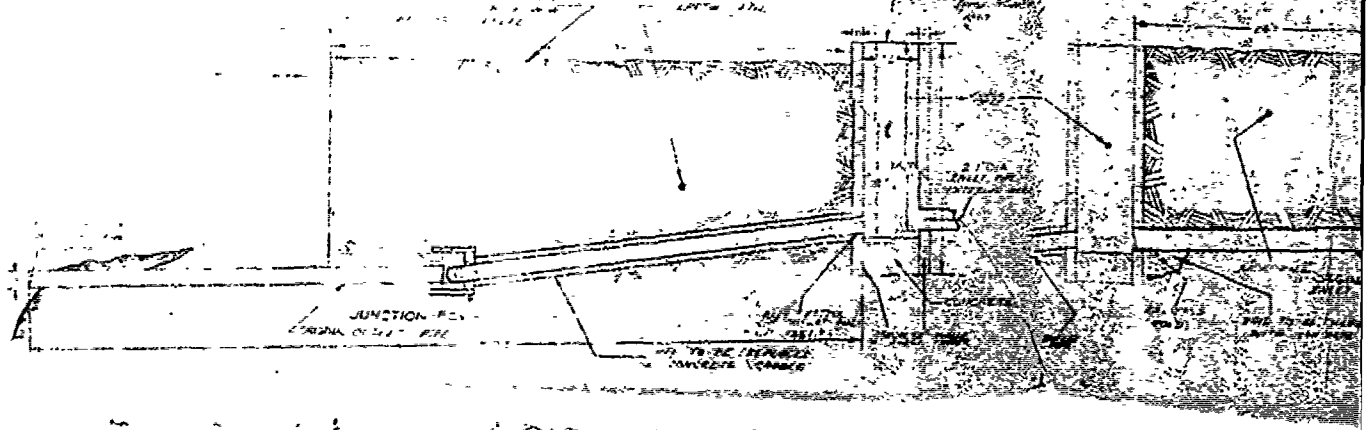
DENALI E

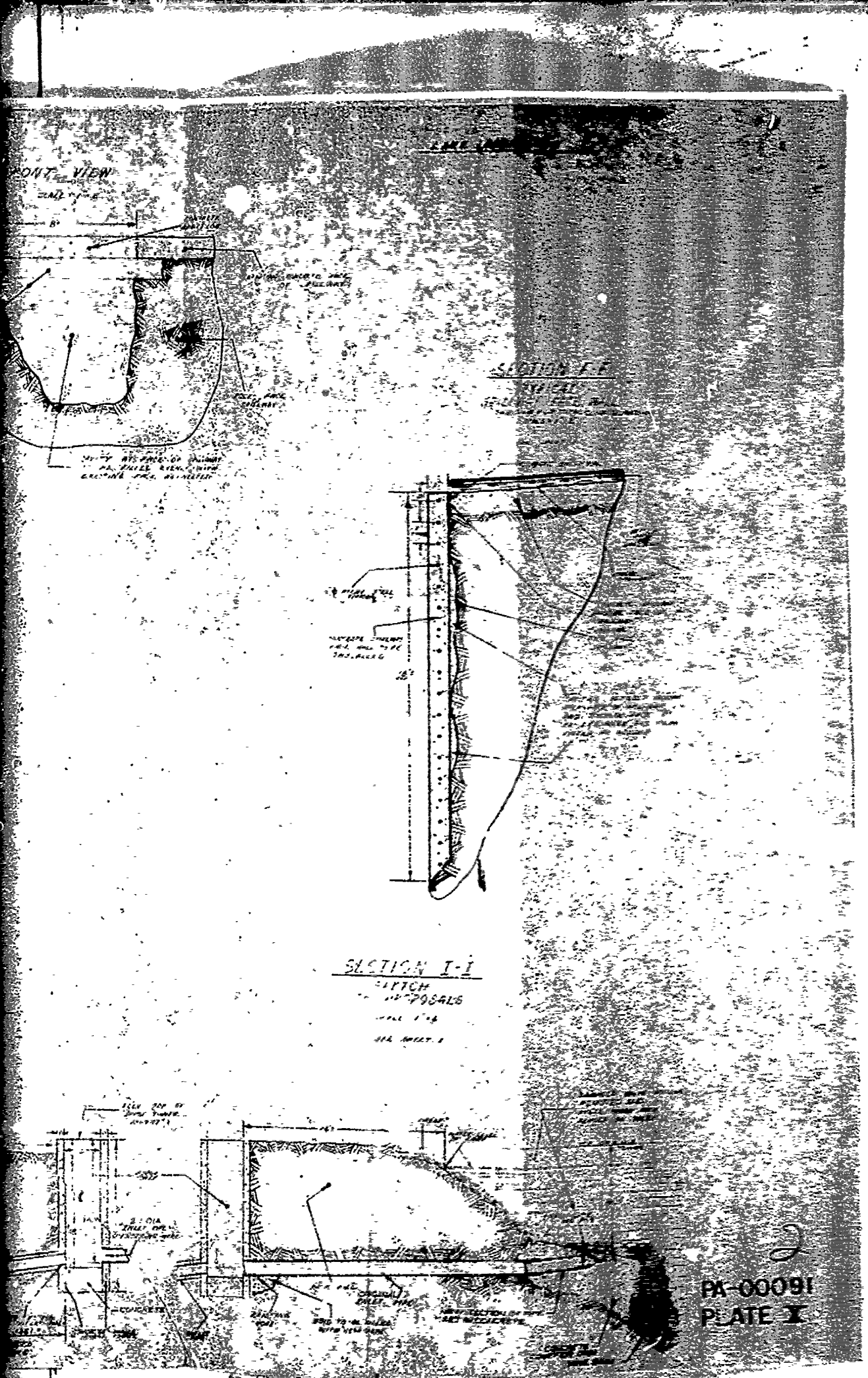
RAISED PORTIONS OF SPILLWAY



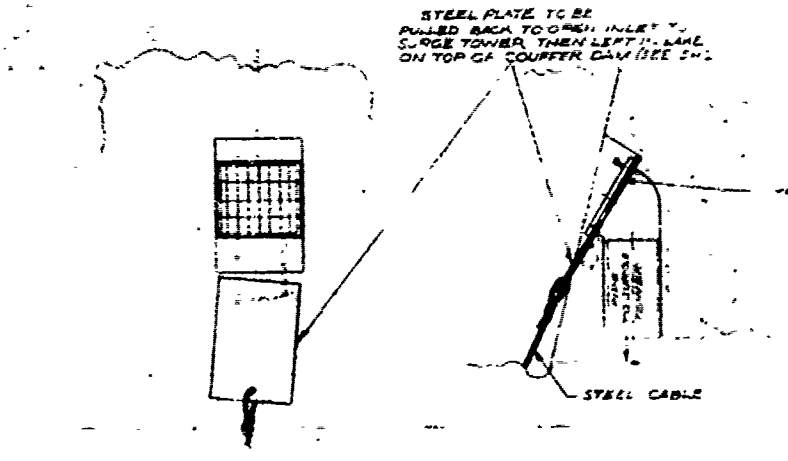


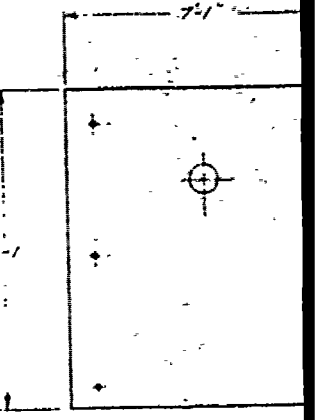




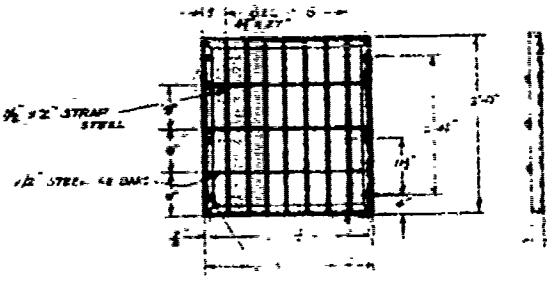


PA-00091
PLATE I

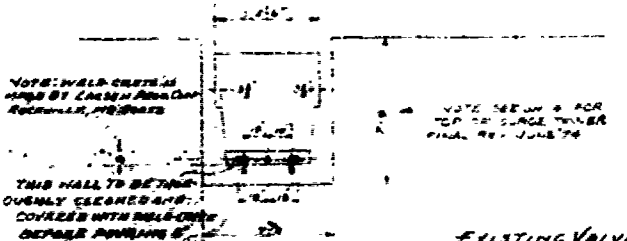




SURGE TOWER C
¼" THK STEEL SEE SH

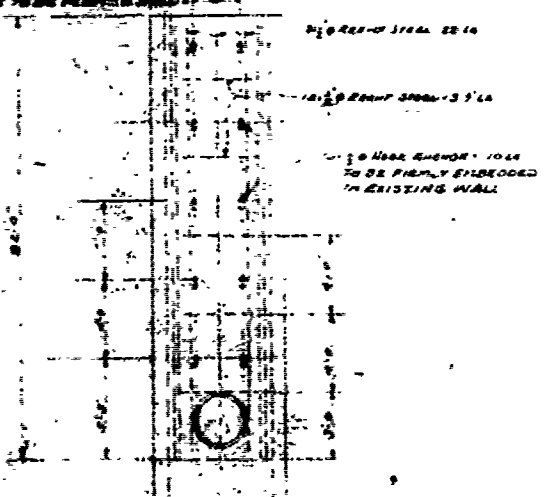


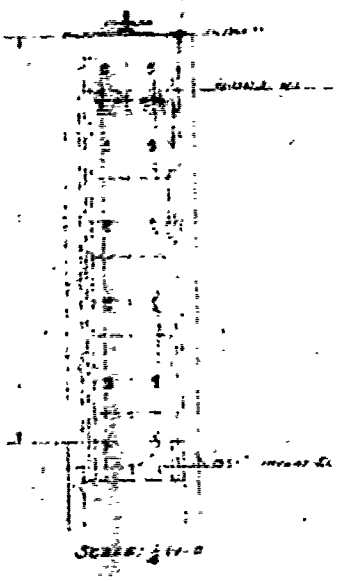
STEEL TRASH GATE



NOTE SEE SH 4 FOR
TOP OF SURGE TOWER
FINAL ELEV JUNE '74

EXISTING VALVE BOX



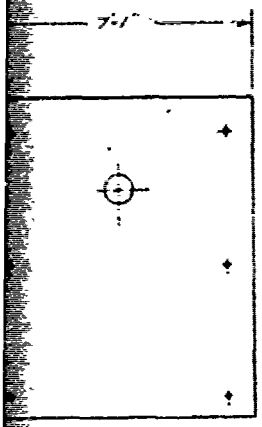


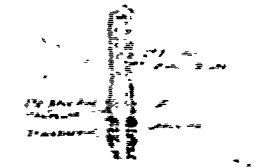
SCALE: ¼"=1'-0"

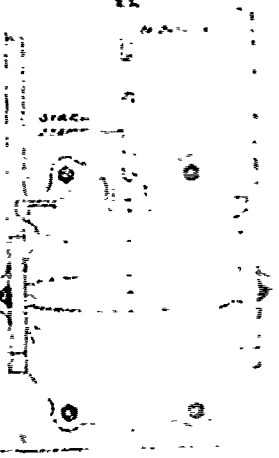
NOTE: THIS PROJECT SHALL BE DONE IN TWO STAGES AS FOLLOWS:
STAGE 1: RE-ALIGN DOWNSTREAM WALL OF VALVE BOX WITH CONCRETE,
AND INSTALL NEW VALVE. FIRST CONTRACT COVERS THIS STAGE ONLY.
STAGE 2: REMOVE OLD INLET FROM LAKE ERIE AND SEAL WITH PIPE,
REMOVE OLD VALVE HOUSE, INSTALL NEW TRASH GATE. SECOND CONTRACT ONLY.

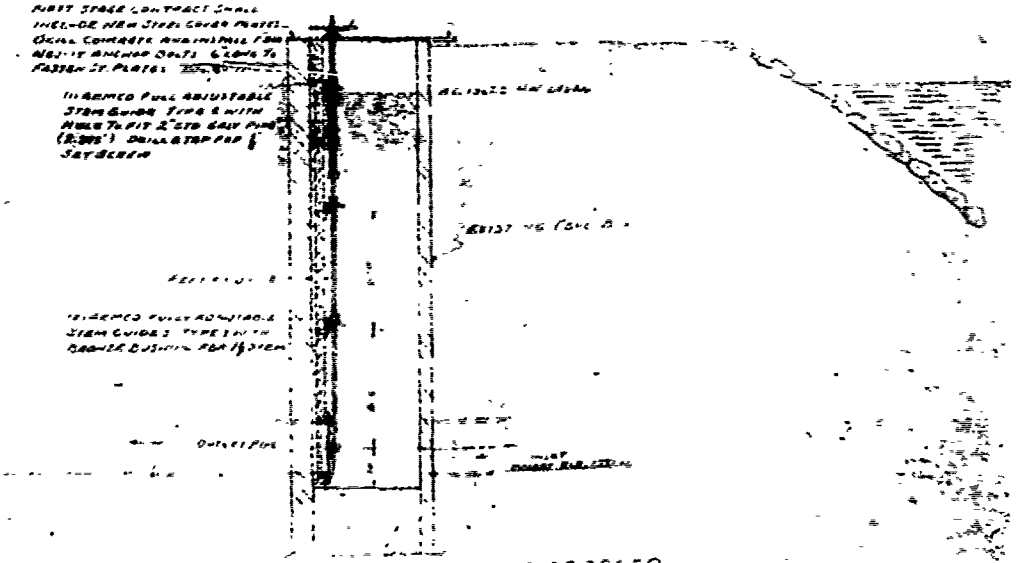
NOTE: CONTRACTOR SHALL CHECK AND VERIFY ALL DIMENSIONS AT

SHEET 3 OF 4



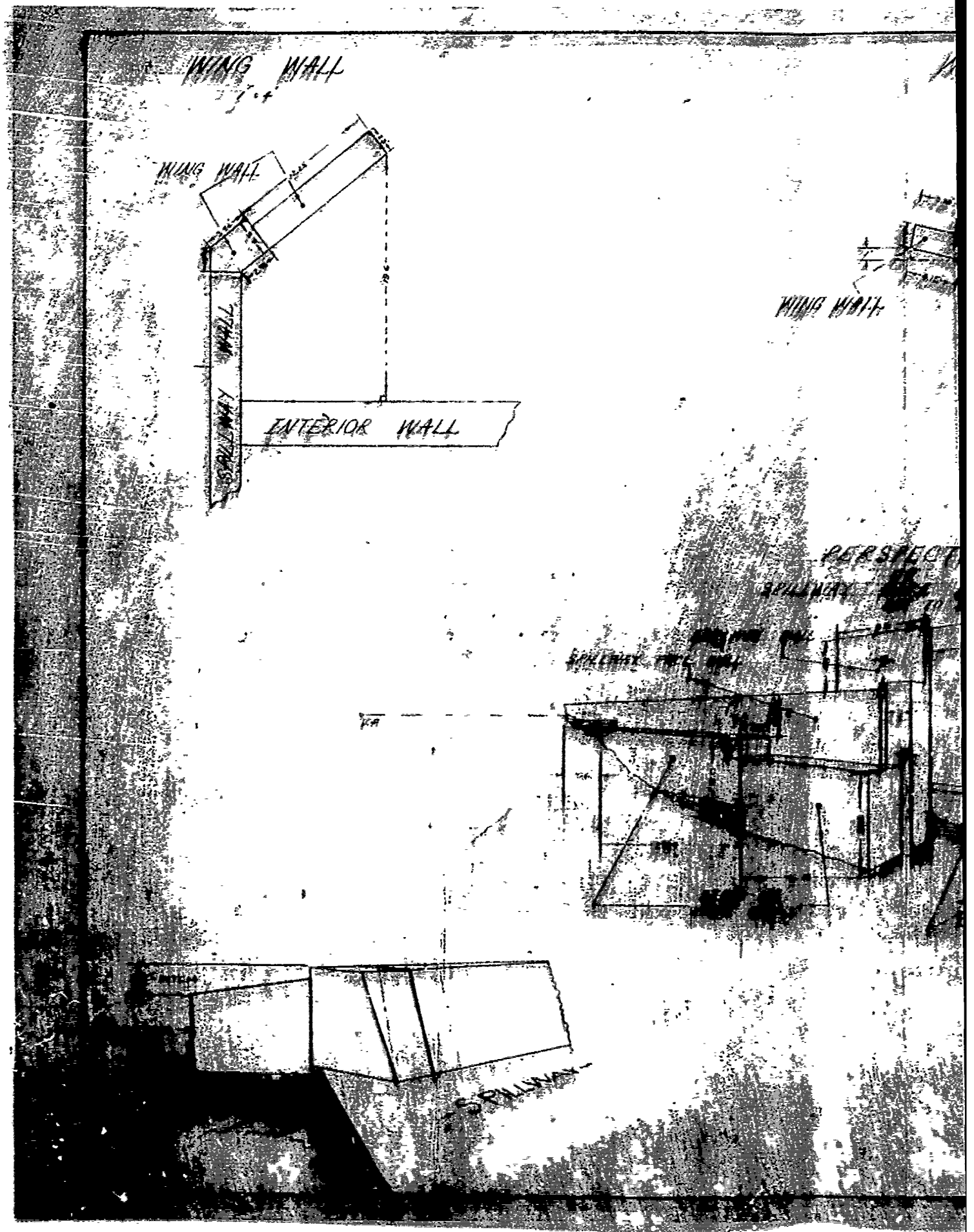






PROPOSED
INSTALLATION OF NEW DRAW DOWN GATE
TO REPLACE PRESENT NON-EXTRACTABLE VALVE
LAKE LADORE - STEENE WATER CO. PA
OWNER: SALVATION ARMY - DEC. JAN 1972
SCALE: AS SHOWN

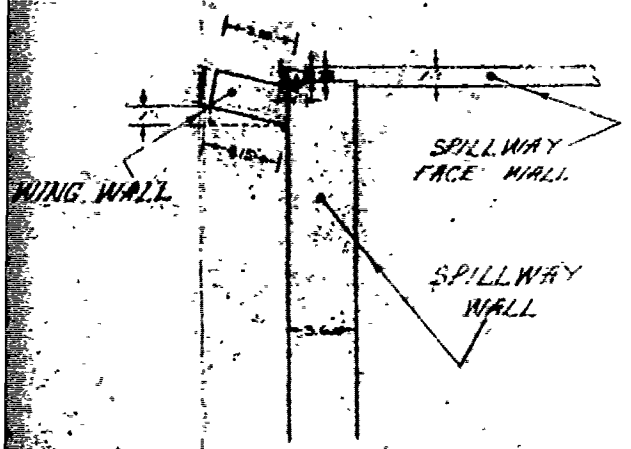
PA-00091
PLATE XI


WING WALL
WING WALL
SPILLWAY WALL
INTERIOR WALL
WING WALL
SPILLWAY

SHEET # OF #

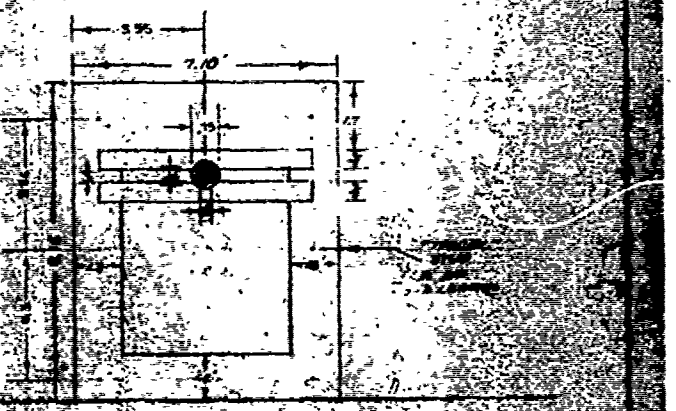
WING WALL

1" = 4'

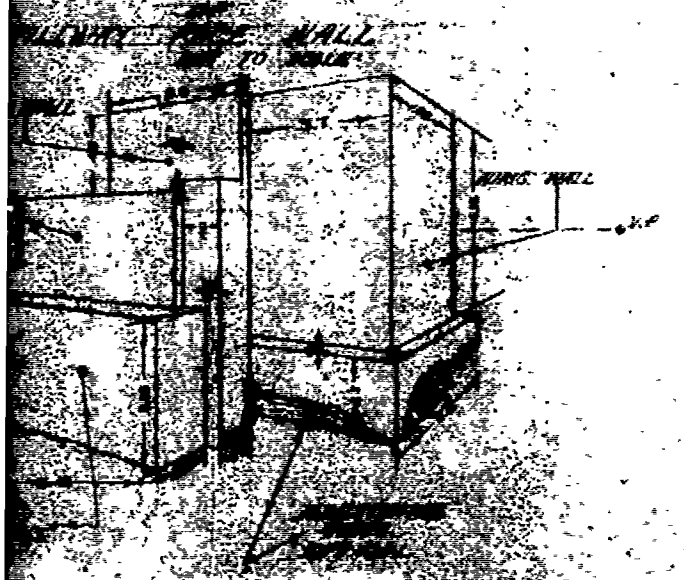


SURGE TOWER

SCALE: 1" = 2'



PERSPECTIVE



LAKE LADORE CONTOUR

PA-000
PLATE

APPENDIX F

GEOLOGIC REPORT

GEOLOGIC REPORT

Bedrock - Dam and Reservoir

Formation Name: Packerton and Poplar Gap Members of the Catskill Formation.

Lithology: The contact between the Packerton-Poplar Gap Members and the undifferentiated Catskill Formation is defined by a conglomerate layer up to 20 feet thick, composed of quartz pebbles in a coarse sand matrix; generally gray in color. Beds are two to four feet thick. It is overlain by gray to graying red sandstone in beds one to four feet thick. The quartz sand grains are in a silt and clay matrix. Some thin siltstone interbeds are present.

Structure

The dam site lies within the Pocono Plateau and the beds are essentially horizontal. There is a small regional dip to the west, toward the Lackawanna Syncline. The N55°E5°NW strike and dip mentioned in the 1917 inspection report is probably cross bedding. The same report mentions vertical joints. A distinct pattern of joints in the bedrock, striking about N10°W on the hill just east of the dam, can be seen on the air photos. Other fracture traces trend N20°E.

Overburden

This dam is really two dams, the original earth and masonry dam built in the eighteen hundreds and a concrete gravity dam built in 1907. No detailed description, borings, or other foundation information is available for either dam. Although the area is within the limits of Pleistocene glaciation, overburden is apparently thin. Outcrops are plainly visible on the air photos, especially on the hill east of the dam. The concrete dam foundation was excavated by blasting "at least four feet into tough green sandstone, more where necessary to eliminate fissures and voids".

Aquifer Characteristics

The conglomerates and sandstones of the Packerton Member are generally of low permeability and ground water moves generally along bedding planes and fractures. The intersection of two sets of fractures, N10°W and N20°E at the dam site provide a potential zone of permeability of some magnitude.

Discussion

There is considerable evidence that there are a number of open vertical joints making a high angle to the dam axis which allow leakage under the dam. Some of these joints are visible on the air photos. Various construction reports mention "fissures", "voids", "joints", etc. Various efforts were made to close these openings, but there is no evidence that pressure grouting was ever attempted.

The bedrock is, for the most part, hard, sound rock and is not likely to be significantly eroded by even large leaks under the dam. The joints do provide, however, a pathway for water to enter the earth embankment, and the fill between the two dams from below.

Sources of Information

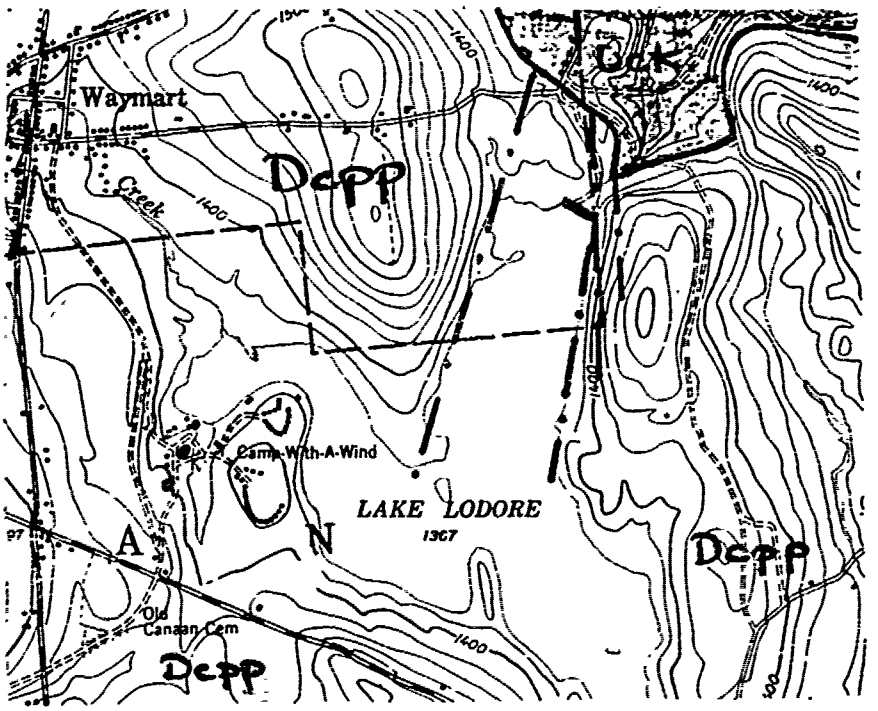
1. Manuscript geologic map of the Waymart Quadrangle, in open file, Pa. Geological Survey, Harrisburg, Pa.

2. Berg, T.M. (1977) "Geology of the Pocono Pines and Mt. Pocono Quadrangles". Pa. Geological Survey, 4th series Atlas 204cd.

3. Air Photos, scale 1:24,000, dated 1969.

4. Inspection reports and correspondence in file.

GEOLOGIC MAP - Lake Ladore Dam



key

Dck — Catskill Fm. - undifferentiated

DcPP — Catskill Fm. - Packerton member through Poplar Gap member

—·—·— air photo fracture trace

SCALE 1:24000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET